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Teacher Tools & Resources

OpenSciEd

MIDDLE SCHOOL SCIENCE

OpenSciEd
Teacher Tools & Resources

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About the OpenSciEd Teacher Tools and Resources

Each OpenSciEd unit has customized tools and resources that are designed to support the development and use of different aspects of the Next Generation Science Standards (NGSS). Additionally, the program has embedded supports to help students track and assess their progress, provide peer feedback, or engage in productive classroom discussions. Finally, the program has resources for you, the teacher, to reflect and plan for future instruction. While each unit has customized these resources and tools specific to the phenomena or design problems in the unit, this document provides a collection of all those tools and resources that can be used and customized in any way for other units. The intention of this resource is to provide you with ideas and resources to modify units or provide additional scaffolds for your students.

This document is organized into clusters of resources but you will see that many resources overlap with other areas. For example, a tool or template under **Section A. Resources and Tools to Support the Science and Engineering Practices** might also include ideas for supporting the cross-cutting concepts.

A. Strategies & Tools for Supporting the Science and Engineering Practices

Asking Questions and Defining Problems

Asking Questions Tool: Open and Closed Questions

1. What is the question you are working on?

2. What is the purpose of your question? Circle one of the reasons below or write in your reason.

Here are some reasons why people ask questions in science:

- ❏ *We don't understand how the phenomenon (or a part of the phenomenon) works.*
- ❏ *We have a disagreement (in our model or with someone's explanation or argument).*
- ❏ *We need to test an idea we have.*
- ❏ *Other reason: _____*

Close-ended and open-ended questions: Questions that can be answered with "yes" or "no" or with a single word are closed-ended questions. Asking open-ended questions gives you space to figure out more things. Scientific questions are open-ended questions.

3. Is your question close-ended or open-ended? Circle one.

- close-ended (Complete step 4.)
- open-ended (Skip to step 5.)

4. Revise your question to make it an open-ended question. Think about what you want to explain about the phenomenon.

Try using one of these question stems:

- *How does … ?*
- *Why does … ?*
- *What happens when … ?*
- *What happens if … ?*

- *What is the difference between _____ and _____?*

Write your revised question:

5. What information or data do you need to answer your question?

6. How would this information or data help you achieve the purpose you circled in step 2?

Peer or Teacher Feedback

Name: _____ Name of person giving feedback: _____

Provide feedback to another student using the table below.

Criteria	Yes or no?	Feedback and/or suggested revision
Is the question open-ended?		
Does the information or data in step 5 help answer the question?		
Does the question help the student achieve their		

purpose for asking the question?		

Asking Questions Tool: Testable Questions

1. What is the original question you want to investigate?

Testable questions: Scientists develop testable questions when they want to collect evidence about a phenomenon or problem. To do this, they need to know what to observe or measure to answer their question. Here are some examples:

Question	What will be observed or measured to answer the question
Where does a jaguar roam in a single day?	Use a GPS tracker to observe the area a jaguar travels in a 24-hour period.
How does the amount of rain in a forest affect plant growth?	Measure the amount of plant growth over time and collect the amount of rain over time.
Is a dog's speed related to the length of its legs?	Measure the length of different dogs' legs and measure how fast they run the same 100-meter course.
How many minutes per day do teenagers use social media apps to communicate with their friends?	Measure the amount of time teenagers (ages 13-19) use social media apps to communicate with friends every day for a week.

2. What do you need to observe or measure to answer your question? (for example: an amount, a length, an amount of time, speed, an area)

3. What additional information do you need in your question about the phenomenon you are studying? (for example: the age of the teenagers in your study, the dog breeds you are testing, or which population of jaguars you are focusing on)

4. Revise your question to include what you wrote in steps 2 and 3.

5. Once you gather this evidence, what new thing do you think you will be able to explain about the phenomenon?

Peer or Teacher Feedback

Name: _____Name of person giving feedback: _____

Provide feedback to another student using the table below.

Criteria	Yes or no?	Feedback and/or suggested revision
Does the question include something observable or measurable?		
Is the question specific enough that you could design an investigation to answer it?		
Does the question help figure out something new about the phenomenon?		

Asking Questions Tool: Experimental Questions

Experimental questions are one type of testable question.

1. What is the original question you want to investigate?

Experimental questions: Scientists develop experimental questions to identify what they want to test or change in an experiment. This is called the *independent variable*. They also include how they are going to measure their results, which is the *dependent variable*.

For example:
How does the amount of light a plant gets in a day affect how tall the plant grows?
(independent variable) (dependent variable)

Here are some example question frames for experimental questions:

How does _____ affect _____ ?
(independent variable) (dependent variable)

What is the effect of _____ on _____?
(independent variable) (dependent variable)

2. Look at your original question. What do you think will cause an effect? This is the variable you will change in your experiment (independent variable).

3. What will you measure to see if the change you made has an effect? This is the variable you will observe or measure (dependent variable).

4. Revise your question to include the variable you are changing (independent variable) and the variable you are measuring (dependent variable).

Use the questions frames above to help you revise your question.

5. If you collect this evidence in an experiment, what new thing about the phenomenon will it help you explain?

Peer or Teacher Feedback

Name: _____ Name of person giving feedback: _____

Provide feedback to another student using the table below.

Criteria	Yes or no?	Feedback and/or suggested revision
Does the question include an independent variable and a dependent variable?		
Is the question specific enough that you could design an investigation to answer it?		
Does the question help figure out something new about the phenomenon?		

Developing and Using Models

Mapping the Model

This part of the _____...	is like this part of _____...	because...	and is not like it because...

Example Modeling Rubric from 8.2 *Sound*

Component	Category			Feedback
Clearly represents or describes the system components and must include:	Missing	Developing	Mastered	
• the **sound source**.				
• the **initial force applied** to the sound source.				
• the **particles of the medium** (air) in between the sound source and detector.				
• the **detector** of the sound.				
Interactions Between Components	**Category**			**Feedback**
Clearly represents or describes the following:	Missing	Developing	Mastered	
• the deformation of the sound source causes the particles in the medium to start moving *(cause/effect)*.				
• that particles in the medium go back and forth and hit neighbors (show this with some sort of convention for wiggle) (*cause/effect*), but do not move all the way from the source to the detector.				
• the repeated nature of this back and forth motion of the shape of the sound source (may identify this back and forth motion as a vibration) *(pattern/structure)*.				
• that the particles of the medium push on the				

"detector", causing it to move *(cause/effect)*.				
• that collisions transfer energy across the medium (the energy moves from the sound source to the detector, but the particles do not move all the way from the sound source to the detector) *(energy).*				
• that particles and the sound source go back to their original starting position *(pattern/structure)*.				

Example Modeling Rubric from 7.3 *Inside our Bodies*

Component Clearly represents or describes the system (digestion and cells burning fat for energy) components and must include at least:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• Bite of food				
• Small food molecules				
• Blood				
• Cells				
• Fat stores				
• Food molecules (role in making energy)				
• Lungs				
• Oxygen				
• Carbon Dioxide				
Interactions Between Components Clearly represents or describes the following:	**Category**			**Feedback**
	Missing	Developing	Mastered	

• the digestion of food chemically breaks down food from big molecules into small molecules				
• the digested food molecules are absorbed by cells and/or travel around the body through the blood				
• cells use the energy they need from food right away through a chemical reaction that uses oxygen from the lungs and releases carbon dioxide (matter/energy)				
• when there are extra food molecules, they are stored as fat that animals can use for energy later (matter/energy)				

Planning and Carrying out Investigations Tools

General Investigation Template

The question we want to answer

Investigation question:

To change, measure, or stay constant?

A variable is a factor you want to change or control in an investigation. There are three types of variables you should think about for your investigation:

- Independent variable - this is the variable to change each time you test.
- Dependent variable - this is the variable to observe for effects caused by a change in the independent variable.
- Controlled variables - these are variables to keep constant in each test.

Discuss the variables with your **group** and write down your variables in your investigation.

Independent variable:

Dependent variable:

Controlled variables:

Plan and conduct the investigation

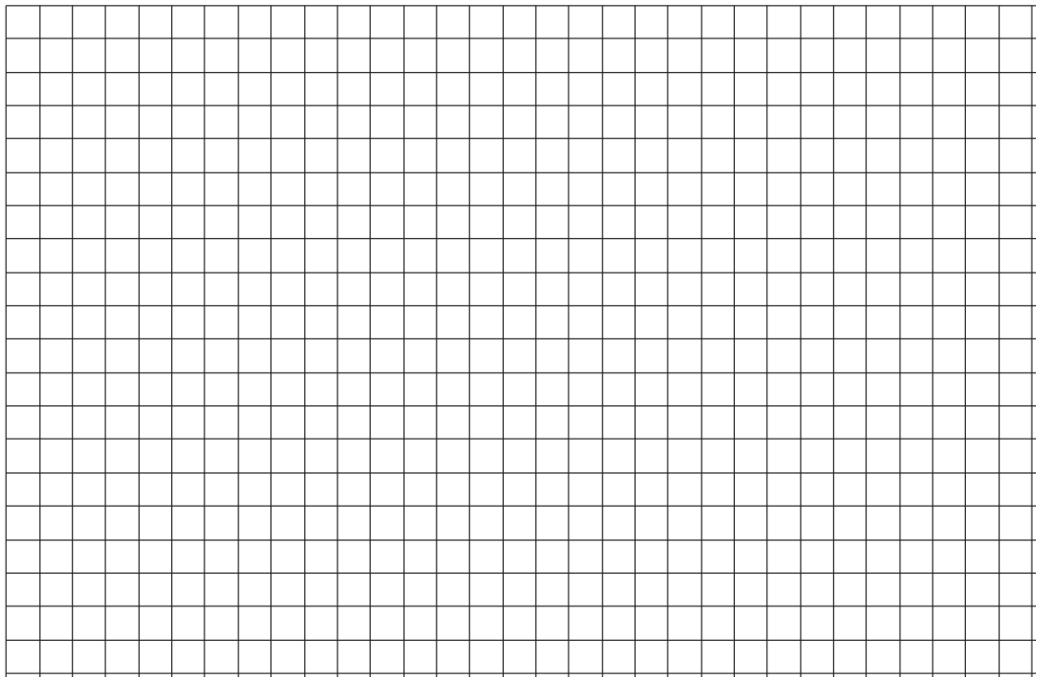
Materials you need:

Steps:

Results: Data table *(students would either have or make this)*

Results: Graph

Look back at how the graph of your data was structured in the previous lesson. Create and label axis and intervals on the grid below so that it will work for graphing your new data.



Interpret and discuss your results

1. Does your data help you answer the investigation question you wrote in your notebook? If it does, write a claim in the space below that answers the original research question your group wrote. If it does not, make a statement to that effect.

2. What evidence did you find from your investigation to support this claim? If you did not have the necessary evidence to make a claim, explain why your data did not help you answer the question, and what additional data you would need.

Peer Feedback on the Investigation Plan

Check if Present	Investigation Plan Includes...	Peer Written Feedback
❑	An investigable research question, and when appropriate, a hypothesis that predicts an outcome with reasoning connected to a science idea	
❑	Clearly identified independent and dependent variables	
❑	Identification of what will be controlled in the investigation, when appropriate	
❑	A description of the tools needed to collect data including units of measure	
❑	A summary of how measurements will be recorded	
❑	A plan/space for how the data be organized and visualized (for example, data table, graph, or some other way)	
❑	A plan/space for how many data are needed to support a claim	
❑	A list of potential sources of error in data collection	
❑	A description of potential issues/challenges with data collection	
❑	A description of what they expect the data will look like if it supports the hypothesis/answers the question	
❑	A description of how to carry out the investigation, described in a way that another student or scientist could carry out the investigation from the plan	

Analyzing & Interpreting Data & Mathematics and Computational Thinking

Working with Data Template

Scientists and engineers collect data from investigations to understand what is going on and to construct arguments from evidence gathered from those investigations. Data by itself does not have meaning, scientists need to organize, analyze, and interpret their data to be able to communicate results to other scientists and the public.

What do you need to do when organizing, analyzing, or interpreting data? Use the table below to help you decide which tools you need.

Purpose	What checklists do I use?
I need to show patterns or relationships in my data...	**Organizing Data**
I need to decide how to visualize or represent my data...	**Organizing Data**
I need to describe patterns or relationships in my data...	**Analyzing Data**
I need to use mathematics to make sense of data...	**Analyzing Data**
I need to compare and/or synthesize across large data sets...	**Organizing Data + Analyzing Data**
I need to use digital tools to identify relationships in data…	**Organizing Data + Analyzing Data**
I need to understand what my data means for the investigation/phenomenon…	**Interpreting Data**
I want to decide if I can use data to make a claim or as evidence...	**Interpreting Data**
I need to describe why my data are important…	**Interpreting Data**
I need to communicate my data and findings to my peers	**Organizing Data + Analyzing Data + Interpreting Data**

Once you decide what tool you need, use the tools below when you are looking at data and using mathematics and computational thinking. Each tool has a checklist of things to do EVERY TIME you are doing the practice and things to do WHEN APPROPROPRIATE. As you do the practice, check the box and respond to any questions in the right hand column to help keep track of your work.

ORGANIZING DATA

Every time...	
❑ Determine the purpose of using this data	Why are you using this data? What is the purpose of this data for your investigation/phenomenon?
❑ Select a way to display the data that will be most useful to you	Select the data display method(s) that will be most useful to you: (Check all that you will use.) ❑ Data table ❑ Graph ❑ Map ❑ Other visual representation: _____ ❑ Mathematics, including: _____ Describe why the methods you selected above will help you connect the data to your purpose for using the data: If you are using secondhand data, is the data represented in a way that will be most useful to you or do you need to reorganize it for your specific purpose?
When appropriate…	
❑ Create your data table	What data should be included in the table? What can be left out? What are your table headings?

	What units will you use for your data values?
❑ Construct a graph or chart from your data	What are the axes of your graph/chart? How does this graph/chart help you see patterns or relationships in your data?
❑ Decide if the organization of your data is helping you	Is there a different way to organize, visualize, or represent your data that would help you see patterns more clearly?
❑ Decide how you will compare across multiple datasets	What are the similar characteristics of your datasets? What do you need to do to them (for example: create graphs, create tables, compare mapped data, , use mathematics) to be able to compare or synthesize them? Why is comparing or synthesizing across these datasets important? How could this help you answer your question?

ANALYZING DATA

Every time...	
❑ Identify patterns in your data	What patterns do you see in the data? If you have a data table, what patterns do you see when you: ❑ Look down the columns? ❑ Look across the rows? If you have a graph, what patterns do you see when you: ❑ Look left to right? ❑ Look up and down? ❑ Zoom out and look at the entire graph? If you have mapped data, what patterns do you see when you look at: ❑ Different locations or places ❑ Different landforms or geographical features (mountains, rivers, oceans, etc.) ❑ Spatial scale (zoomed into one location or zoomed out to a larger location) ❑ Time scale (a short amount of time compared to a longer amount of time)
When appropriate...	
❑ Identify relationships in your data	What relationship are you trying to understand? Complete the sentence: I am trying to understand the relationship between _____ (A) and _____(B). What pattern do you see between _____ (A) and _____(B)?

❑ Identify linear and nonlinear relationships	Does your data have linear or nonlinear relationships? Which patterns do you see in your graph: ❑ Straight lines or you can draw a straight line through your data (linear) ❑ Curved graphs or you cannot draw a straight line through your data (nonlinear)
❑ If using a simulation, determine how the simulation produces results.	What components are in the simulation? What relationships are present in the simulation? How does the simulation know what to do to create results that show the relationship you described? What underlying mathematics do you think the simulation relies on? You do not need to do calculations, use this space to describe the mathematics you think the simulation uses.
❑ Use statistics to analyze data	What mathematics are best suited to give you insights into your data? (Check all that you will use.) ❑ Mean ❑ Median ❑ Mode ❑ Variability ❑ Rate ❑ Ratio ❑ Other: _____ How will using the mathematics you chose help you to make sense of your data?

❑ Use online or computer-based tools to mathematically analyze data	Why do you need an online or computer-based tool from the internet or computer to analyze your data? Which tool will you use and why?

INTERPRETING DATA

Every time...	
❑ Connect back to the purpose of using your data	For what purpose were you using data? What patterns did you expect to see in your data (expected)? What patterns did you see in your data (unexpected)? What does this tell you?
❑ Determine what the data means in the context of your investigation or phenomenon	What do the patterns or relationships you uncovered mean for your investigation or the phenomenon?
When appropriate...	
❑ Determine what the	For every pattern you identify, what does that pattern in your data mean? Complete the following for each pattern:

patterns in your data mean.	**What I see:** | **What it means:**
❑ Decide if you can make a claim using your data as evidence	What claim, if any, can you make that your data supports? Describe how your data supports your claim:
❑ Determine if your data shows causal or correlational relationships	What relationship are you investigating? Complete the sentence: I am investigating the relationship between _____ (A) and _____(B). Can the study design (where the data came from) provide evidence as to whether A causes B? Explain why or why not. If yes, what evidence do you have to support the claim that A **causes** B? If no, what can you conclude right now? What additional evidence is needed to make a causal claim?

❑ Decide how you will communicate about your data	How will you communicate the patterns and relationships in your data to your peers?

What I See and What it Means (WIS/WIM) strategy

Example from Unit 7.6 Droughts and Floods

Part 1: Prepare to Analyze and Interpret Data.

Before you analyze the data, do the following:	Your notes:
1. **Read about the data** sources. ● Consider your purpose: Why are you using this data? How might it help you understand floods and droughts?	
2. What **component of the Earth's Water System Model** does this community rely on and/or have problems within the community?	

Part 2: Analyzing Data. Write or annotate <u>on the graphs</u> on the next page as you consider what you notice or see in the data (WIS) and what it means (WIM).

As you analyze the data, do the following:
3. **Annotate (write and draw) on the graphs "what I see" statements (WIS)** to highlight your observations of the data shown in part 2. Observations might include high points in the data, low points in the data, the direction of data lines, or other observations you might have about

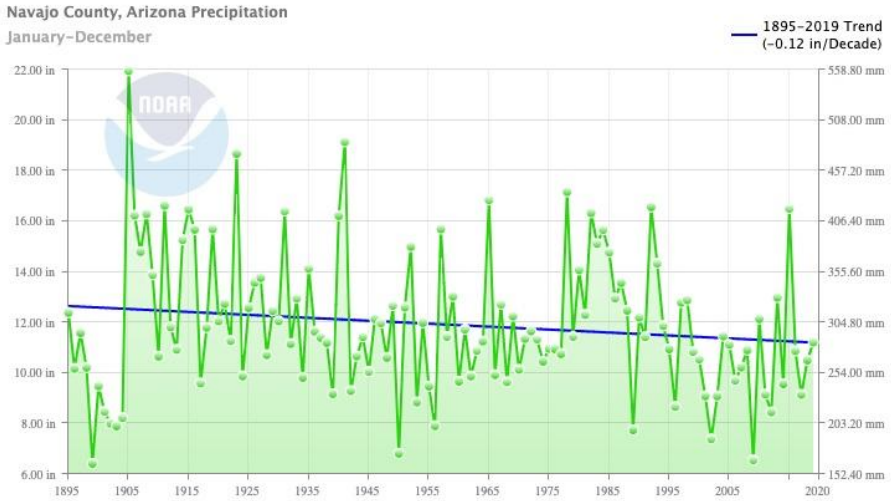
the data you see on the graphs or maps. Write the WIS statement directly on the graph near your observation. Draw an arrow to indicate exactly what data or part of the graph you are writing about.

4. Begin **interpreting what you think the data means by writing a "what it means" statement (WIM)** for your case site on the data in part 2. For each of your WIS statements, write a WIM statement as an interpretation of what you see and the data you reference. WIM statements can also include overall trends you see across the data set or specific patterns in the data. Try to describe what the data means to you.

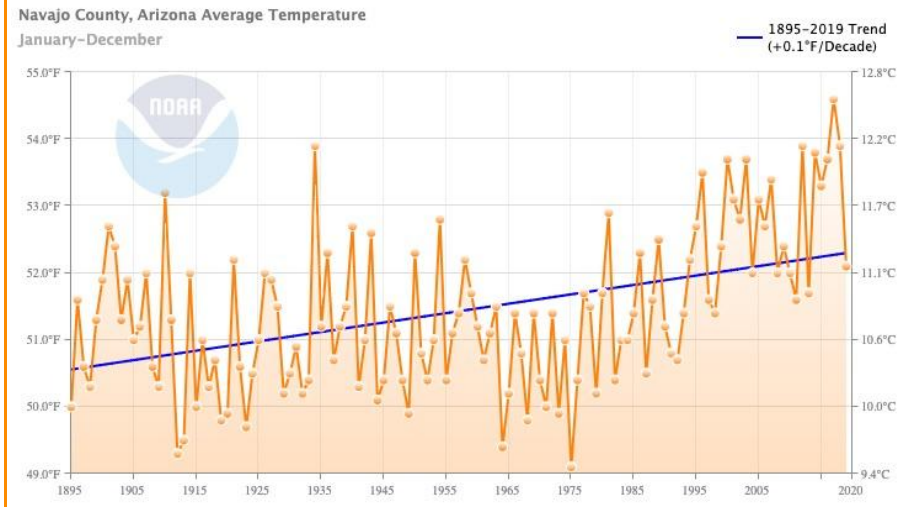
5. Consider what **other types of data** you might want to look at as well or **new questions** that you have. Note those ideas in part 3.

Part 2 continued: Data to Investigate. Write or annotate on these graphs as you consider what you notice in the data (WIS) and what it means (WIM).

Total Annual Precipitation (1895-2020)

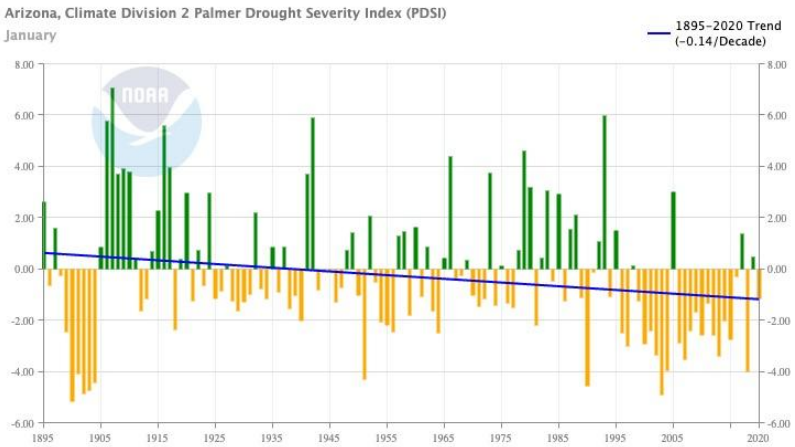


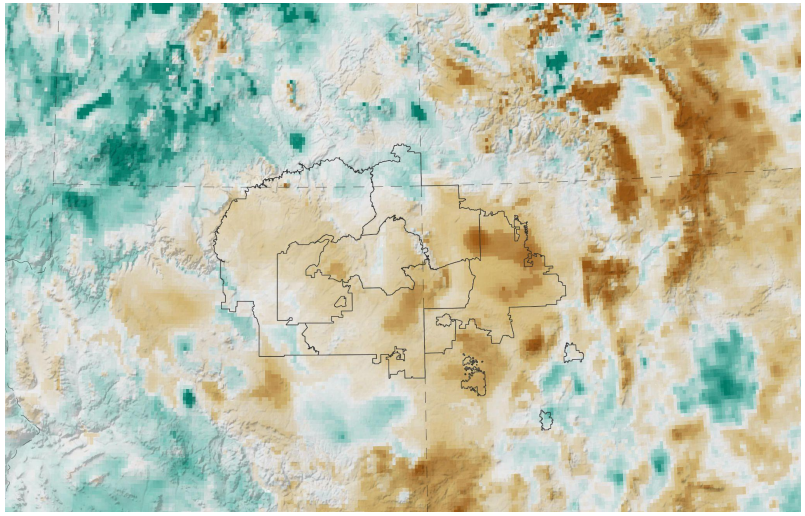
Average Annual Temperature (1895-2020)



Palmer Drought Severity Index (1895-2020)

Drought Severity Map





Part 3: Record Your Graph Captions. Describe what the graph tells you about the location. Summarize your WIS and WIM statements and include the short-term variability and long-term trends in your caption. Record your teammates' captions as well.

Data Source	Data Source Captions	Questions I have:
Total Annual Precip.		
Average Annual Temp.		
PDSI		
Drought Severity Map		

Part 4: Synthesize All Data Sets. Discuss with your team how and what you will share with the class. Start by sharing your location and a summary of the case site. Use the table below to help you plan what you will share about the data. Be sure to connect the data to problems that the site is experiencing.

Communicate Claims and Evidence	Your Notes:
What claim, if any, can you make about what is happening with precipitation (including droughts or floods) at your case site? How does the data support your claim?	
What claim, if any, can you make about what is happening with temperatures at your case site? How does the data support your claim?	
How will you communicate the patterns and relationships in your data to your peers?	

Constructing Explanations and Designing Solutions

Scaffolded Explanation Template
Example from 7.6 Droughts and Floods

Your Role: To create a clear and convincing explanation to others to (1) explain how or why water is changing in one community and (2) support the how or why with evidence.

Consider your Audience: _____ Choose your Format: _____

Think about the Topic: The question it needs to answer is:

How are rising temperatures changing water stories in _____ community?

Be sure your explanation includes:
- Is this normal or not normal for this place? How do you know?
- What does the data say about how things are changing (or not)?
- How or why is this happening in this community?

Helpful sentence starters for constructing your explanation include:
- The sources of water used by this community include...
- The temperature data shows a long-term pattern of...
- The precipitation data shows a long-term pattern of...
- The other data shows...
- This means...
- When temperatures rise, evaporation is affected by...
- This community's water story is affected by...

If writing an explanation, use the space below to jot down some notes. Then write your explanation on the next page. If using a pictorial format or diagram, use a blank sheet of paper to plan and draw your ideas.

Self Assessment and Peer Feedback on Explanations

Does the explanation include the important elements?

Important elements of scientific explanations	Self-assessment	Peer feedback: Use a colored pencil
1. Does the explanation explain how or why the phenomenon works? **Tips** • Did you include all the important parts in the system? • Did you include how the parts interact?	Underline places where you explain how or why. Make notes of where you can improve your how or why explanation. Think about the science ideas you may want to add.	Are the underlined parts where they explain how or why? If so, add a check mark. Are there additional places where they explain how or why but did not underline them? If so, underline them. Could their explanation be improved by using more science ideas? If so, which ones and where would you add them?
2. Does the explanation include evidence from classroom investigations (labs, readings, videos) to support the science ideas?	Circle evidence that you used. Make notes about where you could add more evidence to support your explanation.	Are the circled ideas examples of evidence? If so, add a check mark. Is there additional evidence that is not circled? If so, circle it. Could the explanation use more evidence to support it? If so, add suggestions of what evidence could be used and where to use it.

Based on self-assessment and peer feedback, consider how to revise the explanation: What should be added? What should change?

Explanation Rubric

Example from Unit 6.1 One-way Mirror

How or why account	Category			Feedback
	Missing	Developing	Mastered	
Uses the following science ideas to explain why the music student sees themself **and** why the music student does not see the adults: • When light shines on an object (the music student, the adults), it is reflected. • About half the light reflects off the one-way mirror and half transmits through it. • We see objects when light reflects off them and enters our eye. • When a light input is detected by sense receptors in our eye, it is turned into a signal that travels to the brain. • Less light enters the music student's eyes that reflected off the adults than light that reflected off the music student. • When there are multiple light inputs entering the eye, they are turned into signals, but the brain responds to the strongest signal.				

Based on evidence	Category			Feedback
	Missing	Developing	Mastered	
Evidence from classroom investigations (labs, readings, videos) supports the explanation. • Measuring Light Lab from Lesson 3 shows about the same amount of light transmits through and reflects off the one-way mirror • Half-silvered structure of the one-way mirror from Lesson 4 reading • Video and reading from Lesson 6 about the eye and brain • Observations using the box models from Lessons 1, 2, and 3				

Revised explanation	Category			Feedback
	Missing	Developing	Mastered	
Uses feedback from self and peer assessment to revise the explanation: • Includes a revised explanation that is clearly improved • Includes a reflection of why a change was made • Includes a reflection on a piece of feedback they did not use, if				

applicable				

*The "Developing" section of the rubric represents students who may have several important ideas described in the rubric that indicate progress toward mastery but there is still something notably missing in their response. "Missing", on the other hand, indicates their response is missing many important ideas described in the rubric.

Engaging in Argument from Evidence

Argument Rubric from *Inside Our Bodies*

Claim	**Category**			**Feedback**
	Missing	Developing	Mastered	
• **There is a claim** that states that M'Kenna has Celiac Disease.				
Justification **Evidence or empirical data** that supports the claim includes:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• M'Kenna's endoscopy images of her small intestine look differently than the healthy small intestine images				
• Graphs show that M'Kenna is breaking down all large food molecules except for all "other complex carbohydrates"				
• Graphs show M'Kenna has food molecules left in her large intestine and poop, that are not found in a healthy person				
• M'Kenna has flat villi in her small intestine				
Scientific principles or ideas that explain how each piece of evidence supports the claim (*reasoning*) includes:				
• Since there are structural differences in the small intestine images, this indicates there could be a difference of M'Kenna's function of her small intestine				
• Since small molecules are not being absorbed by the small intestine, they continue moving down her digestive tract and end up in her poop				

• The food molecules are being broken down in M'Kenna and in a healthy person because we see large food molecules in the graphs go down and small food molecules go up, but then in M'Kenna they all are not being absorbed because food molecules are still left in her poop and large intestine				
• Flat villi make it more difficult to absorb food so small molecules are left over in the process as food moves through the body. The villi are the cells of the digestive system in the small intestine where food is absorbed. When functioning properly, villi increasing the surface area in the small intestine where small food molecules can be absorbed (*structure/function)*				
Rebuttal Clearly represents or describes the following:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• a critique of the evidence of an alternate claim ○ Not other diseases because the damage located in the small intestine ○ The other small intestine diseases are not caused by damage to the villi structures ○ Any other valid critique that relies on evidence				
• a critique of the reasoning of an alternate claim ○ The disease M'Kenna has must be related to the small intestine because that is where we knew there was damage from the images we examined ○ The disease M'Kenna has must be a result of or related to the damage of villi in the small intestine because we know that the damage villi absorb small molecules less efficiently than normal villi which can explain why we see small molecules in M'Kenna's poop. ○ Any other valid critique of reasoning that students propose				

Obtaining, Evaluating, and Communicating Information

Close Reading Protocol

Before	1. Identify the question(s) you are trying to answer in the reading.
During	2. Read once for understanding to see what the reading is about.
	3. Read a second time to highlight a few key ideas that help answer the questions you had.
After	4. Summarize the key idea(s) in your own words, in diagrams, or both.
	5. Jot down new questions that this raises for you.

General Obtaining, Evaluating, and Communicating Template

Scientists spend much of their workdays obtaining, evaluating, and communicating information. Often that information comes from papers, graphs, images, and other data representations that other scientists publish. Sometimes they read science news articles. Scientists often give talks and posters to share their ideas and get feedback. They do not just obtain, evaluate, then communicate information. They use all sorts of combinations to do their work.

What do you need to do with scientific texts? Use the table below to help you decide which tools you need.

Purpose	What checklists do I use?
I need to gather information from an article...	**Obtaining Information**
I want to know if I can trust a source…	**Evaluating**
I need to compare and/or synthesize multiple texts…	**Obtaining Information** + **Evaluating**
I want to decide if I can use a source to make a claim or as evidence...	**Obtaining Information** + **Evaluating**
I already have all my ideas but I need to share them and get feedback...	**Communicating**
I am starting from the beginning and need to present my ideas to my peers	**Obtaining Information** + **Evaluating** + **Communicating**

Once you decide what tool you need, use the tools below when you are obtaining or evaluating or communicating information. Each tool has a checklist of things to do EVERY TIME you are doing the practice and things to do WHEN APPROPRIATE. As you do the practice, check the box and respond to any questions in the right hand column to help keep track of your work.

OBTAINING INFORMATION FROM SCIENTIFIC TEXT

Every time...	
❑ Read for the gist - skim the title, headings, images	What is the central idea or claim?
❑ Markup the text	Select methods for marking the text. For example… ❑ Keep track of questions you have in the margins. ❑ Circle key words. ❑ Put question marks by words you want to learn more about. ❑ Underline main ideas.
❑ Examine any images, graphs, or tables.	Write one sentence about the central point of each image, graph, or table.
When appropriate…	
❑ If the text is about research, ask yourself questions about the text, like:	What questions were the authors asking? What evidence did they collect? Does the evidence support their claims?

❑ Examine where the authors obtained their information.	What sources did the authors cite?
❑ Identifying the ideas from the text supports what you've figured out so far.	What are the supporting ideas?
❑ Identify the ideas from the text that contradict what you've figured out so far.	What are the contradicting ideas?
❑ Write a short summary of the meaning of the paper.	Write your summary here:

EVALUATING SCIENTIFIC TEXTS

Every time...	
❑ Identify the purpose of the text	Why was this text written?
❑ Identify the goal of the text	What is the goal of the text - To share information, to convince someone of something, to distract people from a larger issue, something else?
❑ Identify the claims in the text	What claims is the text making? Are they supported by evidence? Where does that evidence come from?
❑ Identify what other information you have to compare to this text	Does it make sense or fit?
When appropriate...	
❑ Identify the author	Who is the author? Who do they work for? What other things have they written?
❑ If it is a research study, identify how the study was done.	What methods did the authors use? Are they appropriate for the purpose of the research?

❑ Examine what might be missing	Is there anything missing from the text that you think should be there?

COMMUNICATING IN SCIENCE

Every time...	
❑ Identify the audience you are communicating with	Who is your audience?
❑ Clarify your purpose	What is the purpose of your scientific communication?
❑ Identify the constraints of your communication	What constraints are there for your communication? Does it need to be written, oral, a poster?
❑ Use text, images, tables, diagrams, graphs, equations	Which kinds of communication will you use? What is each medium communicating to your audience?
When appropriate...	
❑ Get feedback	Who will you get feedback from on your scientific communication?
❑ Engage in conversation	Who will you talk to about what you figured out? What is the purpose of this conversation?

❑ Ask questions	What questions do you have about your work or the work of others?

Example from Unit 8.5 *Muscles*

Obtaining information from scientific text	
❑ Read for the gist--skim the title, headings, images.	What is the central idea or claim? _____ _____
❑ Mark up the text.	Select methods for marking the text. ❑ Keep track of questions you have in the margins. ❑ Circle key words. ❑ Put question marks by words you want to learn more about. ❑ Underline main ideas. ❑ _____(another method of your own)
❑ If the text is about research, ask yourself these questions	What question was the author asking? _____ What evidence did they collect? _____

about the text.	_____

Evaluating information from scientific text	
❑ Identify the goal of the text.	What is the goal of the text--to share information, to convince someone of something, to distract people from a larger issue, or something else? _____ _____
❑ If it is a research study, identify how the study was done.	Are the research methods used appropriate for the purpose of the study? Why or why not? _____ _____

Self-assessment for Obtaining, Evaluating, & Communicating Information

Example from 8.5 Muscles

Place a check in each row to reflect on how you used this practice while researching your organism.		Did not do	Sometimes did	Always did
Obtaining information	We identified the gist or central idea for each information source.			
	We identified the details from the information source that supported the central idea.			
	We made sense of information from any relevant images or diagrams that were included in the information source.			
	I contributed to the work of obtaining information.			
Evaluating information	We identified why each source was written or created.			
	We identified evidence supporting the author's/creator's central ideas.			
	We checked that the information is reliable by using any or or all of these steps: ● We found multiple resources cited by the author/creator. ● The ideas in this source align with ideas we have already figured out. ● This author used appropriate study methods. ● We have reasons to trust that this source is credible.			
	I contributed to the work of evaluating information.			
Communicating information	Our presentation met the purpose of communicating information: to share about the organism and how it reproduces asexually.			
	Our presentation was communicated in a way that could be easily understood by those who were hearing it and seeing it.			
	Our presentation fit the constraints of the activity (1-2 min in length).			
	I contributed to the work of communicating information.			

Looking at your responses in the "Obtaining information" section on the chart, how would you rate yourself on a scale of 1 (much improvement needed) to 5 (excellent)? _____

In what ways could you improve next time how you are obtaining information?

Looking at your responses in the "Evaluating information" section on the chart, how would you rate yourself on a scale of 1 (much improvement needed) to 5 (excellent)? _____

In what ways could you improve next time how you are evaluating information?

Looking at your responses in the "Communicating information" section on the chart, how would you rate yourself on a scale of 1 (much improvement needed) to 5 (excellent)? _____

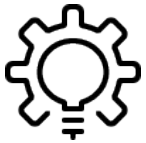
In what ways could you improve next time how you are communicating information?

Communicating in Scientifics Ways Poster

The *Communicating in Scientific Ways* chart is an example of one OpenSciEd resource that provides students with visible sentence stems to help prompt their communication within one another. A large printable version of this can be found at www.openscied.org/communicating-poster/

How we figure things out	Symbol	How we communicate
1. Ask why and how questions		How come …? I wonder …. Why …? How do they know that …?
2. Observe		I see …. I noticed …. I recorded …. I measured ….
3. Organize data and observations		I see a pattern …. I think we could make a graph …. Let's make a chart ….
4. Think of an idea, claim, prediction, or model to explain your data and observations		My idea is …. I think that …. We could draw a picture to show …. I think it looks like this ….
5. Give evidence for your idea or claim		My evidence is …. The reason I think that is …. I think it's true because ….
6. Reason from evidence or models to explain your data and observations		The reason I think my evidence supports my claim is because …. The model shows that ….

		
7. Listen to others' ideas and ask clarifying questions		Are you saying that …? What do you mean when you say ...? What is your evidence? Can you say more about …?
8. Agree or disagree with others' ideas		I agree with ____ because… I agree with you, but I also think... I disagree with _____ because… I know where you are coming from, but I have a different idea... I am thinking about it differently...
9. Add onto someone else's idea		I want to piggyback on April's idea. I want to add to what Jeremiah said.
10. Search for new ideas from other sources		We could get some new ideas from ….
11. Consider if new ideas make sense		That idea makes sense to me because …. That idea doesn't make sense because …. What's their evidence?
12. Suggest an experiment or activity to get more evidence or to answer a new question		What if we ...? We could get better evidence if we ...?

13. Let your ideas change and grow		I think I'm changing my idea. I have something to add to my idea.

B. Strategies & Tools for Developing and Using Crosscutting Concepts

OpenSciEd units support students to transition from highly scaffolded experiences with crosscutting concepts (CCCs) to limited scaffolding. The OpenSciEd materials can support this transition by providing explicit support for CCCs at moments early in an instructional sequence and removing those supports over time as students become more autonomous in their use of CCCs. Ultimately we want students to develop CCCs as strategies for reasoning about science that students can apply to a variety of phenomena-both in and out of school. To do this students must learn how to use these strategies through personal experience, discussion, and practice in developing scientific explanations. Below are a few examples of how our materials can support students in this process:

- *Support students' use of CCCs to ask productive questions about phenomena.* Students tend to struggle in their generation of productive questions. Students also get 'stuck' not knowing what kinds of questions they should ask. CCCs can be used by students to rethink a phenomenon and to identify productive kinds of questions they could ask about phenomena. Suggestions for how to use CCCs to help students generate productive questions are included in OpenSciEd teacher guides.
- *Provide principles and strategies to guide model-building and explanation.* The task of developing a model to explain a phenomenon can be daunting. The OpenSciEd teacher materials provide guidance on how students can apply one or two CCCs in their model building and explanation practice, cueing students to account for key elements they may otherwise miss. Prompts and checklists are provided in student materials to support them in applying these crosscutting concepts and reflecting on how they used them.
- *Sequence students' experiences of related phenomena in ways that engage students in analogical reasoning*. As students encounter new, but related phenomena, CCCs are a way to make sense of the new phenomena even if students are unfamiliar with science ideas necessary to explain the new phenomena completely. Thus, OpenSciEd units are strategic in sequencing students' experiences of phenomena and encourage them to see similarities and differences between these phenomena (analogical reasoning).

The purpose of a CCC is to help move students forward through a science storyline (i.e., We are stuck, maybe thinking about _____ can give us some ideas of what's going on here.) CCCs should always be coupled with other dimensions and not taught as 'stand-alone' concepts. For example, when reflecting on the use of a CCC, it's important to emphasize how the CCC worked in tandem with a practice, or was critical for figuring out a Disciplinary Core Idea (DCI). Take advantage of pairings of CCC with DCIs or SEPs where possible (such as how it is listed in the LLPEs for the lesson), but also look for additional productive pairings such as (not an exhaustive list):

- Systems and system models with modeling
- Patterns with data analysis
- Scale, proportion, quantity with mathematical/computational thinking
- Structure/function with engineering design and/or biological systems

- Cause and Effect with explanations

Resources are integrated into the materials to use CCCs to scaffold student sense-making and discourse. These resources and prompts are found in student handouts, on slides, and in teacher guide callout boxes. Here a few examples to highlight how they show up in the materials.

Example Question Prompts (for more, see STEM Teaching Tool #41, http://stemteachingtools.org/brief/41)

Systems and Systems Models

- What are the key components of the system?
- Are there key components that are invisible?
- How are the components related?
- How do the parts of the system work together?
- What would happen in the system if you increased *X* component?

Structure and Function

- What unique structures does this object/living thing have?
- What function do the structures have?
- How does the structure facilitate the function?
- How does the shape of _____ help it function (or behave)?

Example Slide Resource (from Unit 8.3 Magnets to support Cause and Effect)

	Change (cause)		Effect on the system		How or why
When we		we observe		because	

Examples of Teacher Guide resources

Callout boxes are used to highlight CCCs where they are intended to be developed and/or used to help student sensemaking. In general, CCCs are particularly helpful in these key instructional moments:

- When we are stuck in generating questions, a CCC can help us focus our questions.
- When we are stuck in interpreting data, a CCC can give us a new lens.
- When we are setting a checklist/priorities for what to include in our models.
- When it makes sense to reflect on how a CCC was helpful to our thinking.
- When we are encountering a new, but related, phenomenon we want to see how the new phenomenon is similar to or different from other phenomena we've explained.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SYSTEMS AND SYSTEM MODELS

Systems and System Models sentence starters may include:

- What are the key parts of _____?
- How do the parts _____, _____, and _____ work together?
- What would happen in this system if you _____?

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING PATTERNS

The point of this discussion is not to clarify how similar she is to either one of the others, but rather to clarify that her phenotype is visibly distinguishable as being between the heavily muscled phenotype and the typical-muscled phenotype and to surface the physical details that put her in that category. Then we can decide on a way to represent an individual that appears to be in between our two original phenotypes, or has medium muscles.

If students disagree on how to categorize Fantasie, be sure to encourage them to respectfully critique each other's ideas and to respond by asking clarifying questions and/or using evidence to support competing ideas.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY

Throughout this unit we have been increasing the complexity of our model of the Earth–Sun–Moon system by taking different perspectives and refining our understanding of the relationships between these components. The perspective we're taking now, where we zoom in on a smaller "slice" of Earth's atmosphere to consider how light interacts with it, is a completely new perspective in the unit. Relative to the planetary scale we've been using thus far, this zoom-in helps us consider the Earth–Sun system on a much smaller scale, but obviously not nearly the scale of previous zoom-ins that help us explain interactions at the cellular or molecular level.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT

Encourage students to use the crosscutting concepts of Cause and Effect or Systems and System Models to help develop questions. You may wish to provide Cause and Effect sentence starters such as:

- In the ecosystem, how did _____ cause _____?
- How do _____ and _____ work together to affect _____?
- How does _____ affect _____ and _____?
- What would be the effect if _____?
- What feedback loops are causing this system to _____?
- How can a small change to ___ have a big effect on _____?

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING STABILITY AND CHANGE

Support your students in using a Stability and Change lens during this discussion, by adding probing questions like the ones below:

- How might this system be affected in the short term by the loss of the orangutans?
- How might this system be affected in the long term by the loss of the orangutans?
- How might this system be affected by a change in the seed dispersal throughout the tropical rainforest?
- Is the loss of the orangutan disruptive enough to affect the whole system? Why or why not?

If your students have used Stability and Change frequently during the school year, elicit from them what questions they should ask using this lens that would help them better understand if the system is (or would be) stable or if it would change as a result of alterations to the state of one of its components (the orangutans).

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING STRUCTURE AND FUNCTION

This is a great place to help students begin to see that the structures of organs help give them particular functions. We will continue to build on this idea, and by the end of Lesson 7, we will be able to generalize out that all organs have a particular structure and function. Students should also begin to make connections between food data from the previous lesson and the molecular structure of those molecules in this lesson. They should draw conclusions that the structures of those molecules can affect their ability to move through different organs in the digestive system.

To support students in doing so, refer to evidence from the investigation about how only certain molecules can move through the dialysis tube and how that relates to what we learned about the large structure of starch (versus small structure of glucose). In future lessons, students will continue to examine the relationship between organ structure and function as a determining factor in how food molecules move through the digestive system.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING ENERGY AND MATTER

Students should have completed the *Cup Design Unit*, the *Storms Unit*, or the *Homemade Heater Unit*, and should be prepared to use energy as a lens for explaining the relationship between temperature and evaporation. Consider adding prompts to activate students in using energy as they share initial ideas:

- When we learned about energy and particles before, what did we decide happens when energy is transferred to a particle?
- How can we use energy to explain what happens to particles when they evaporate?
- If the air temperatures are warmer, what does that tell us about the energy of those air particles?

C. Strategies & Tools for Supporting Engineering Design

Initial Design Reflection

From Unit 7.2 Homemade Heater

Take a moment to reflect on the process of creating and sharing your design for a do-it-yourself flameless heater.

1. What went well when creating or sharing your initial design?

2. What was difficult about creating or sharing your initial design?

Example Design Test Matrix

From Unit 7.2 Homemade Heater

	Total cost of heater	Total mass of food + reactants + packaging	Heats food to what temperature?	Time to heat food	How-to instructions
Design solution criteria and constraints	$3 or less	700 grams or less	Heats food to 40-47°C	_____	_____
My team's prototype					

Determining Stakeholders and Needs

From Unit 6.5 Tsunami

Part 1. Identify the stakeholders and their needs.

Consider the following:

- Who are the people that live in places where tsunamis might happen?
- Will they need special help during a tsunami? Describe those needs.
- Who can help them?

Who is this community member? (Stakeholders)	Will they need special help during a tsunami?	Describe their needs.	Who can help them?
	☐ yes ☐ no		
	☐ yes ☐ no		
	☐ yes ☐ no		

Part 2. Define the problem and the goals of a tsunami communication system.

What is the problem that engineers are trying to solve in developing a tsunami communication system?

What would that system need to do to address all the needs of the community members?

Part 3. Identify the specific criteria and constraints for communication systems.

Identify criteria. **What *must* the system be able to do to work?**	**Why is this an important criteria?**

Identify constraints. What might limit what is possible in the communication system?	**Why is this constraint important to consider?** Are there particular community member needs that we should consider?

Final Design Proposal Template

From Unit 8.1 Collisions

Sometimes design solutions have to be pitched to investors to receive funding for the creation of the product. During that pitch, the engineers have to justify their choices and explain why the stakeholder would want to utilize their design (sometimes over other preexisting designs out there). The pitch helps the funders, investors, and product developers see the value in the design. It will also help the advertisement team better market the design to stakeholders.

Use this handout to help you start drafting the key parts of your design proposal pitch.

Part 1: Introduce the problem and claims for a solution

The first thing we have to do in a pitch is establish a purpose. In the space below, tell a little bit about the problem you have identified. Write it so that the investor will feel the need to fix the problem.

Next, you will need to explain the purpose of your device and make a claim about what your proposed design solution will be able to do.

Part 2: Show off your solution

In the space below, show your design solution to investors. Highlight any key features that help meet the needs of the design that separate your device from others.

If there are already devices available to consumers that are meant to protect your object, explain how this design will work better than the devices already on the market.

Part 3: Present your research

Investors and others who you are pitching to will want to know that you have done your research and are making the best choices. They will want to know that you are making decisions based upon stakeholder needs and attitudes, making the device easier to sell.

Explain any feedback you received from stakeholders that you *are* using in your design:

Feedback	Where and how it is being utilized

Explain any stakeholder feedback you *are not* using and why you have made that choice:

Feedback	Why it is *not* being utilized

List any other criteria or constraints you took into account when making this device.

_____

_____

_____

Part 4: Justify your design decisions

Investors will want to know that you have made good decisions in your design. Explain what you ranked as your primary vs. secondary vs. tertiary considerations and why. Explain how these decisions have helped to optimize your design.

Stakeholder consideration	Your ranking (P, S, T)	Explain why this choice helps to optimize your design

Engineering Design Rubric

Team name: _____ Members: _____ Date: _____

Category	Missing	Developing	Secure
Developing a design solution			Evidence from student artifact includes the following: ● A model or design solution that releases energy using a chemical reaction is **fully** developed—**all** materials used in the design are included appropriately in the how-to instructions. (Compare the designs with student instructions) ● The substances and amounts used in the chemical reaction are identified, **including reasoning for those amounts**. ○ aluminum ○ copper sulfate ○ saltwater ● The transfer of energy is **shown using systems interactions or at the particle level** between components of the model or design solution. (Look at student designs.)
Testing design solutions			Student presents evidence to show the following: ● The design solution was tested to see if it met **all** criteria and constraints.
Evaluating design solutions			Student presents evidence to show the following: ● The design solution was evaluated using a Design Testing Matrix that included **all specific** criteria and constraints. ● The characteristics of the design that performed the best in each test are identified **based on data recorded in the Design Testing Matrix comparing multiple designs**.
Combining parts of design solutions			Student presents evidence to show the following: ● Parts of different design solutions **are combined based on evidence** to create a new and improved design solution.
Optimizing design			Student presents evidence to show the following: ● The design solution has been improved based on prior test results, and evidence of those decisions is

solutions			clearly stated or shown using scientific reasoning. • The same tests have been repeated in order to compare designs and continue improving the proposed solution. • Relevant stakeholders **and** trade-offs have been considered in order to optimize the design solution.

Engineering Self-Assessment

Read each statement and circle how well you did it:

1 - I need to work on this, or I did not do it.

2 - OK—this is an area that you did well on but could improve your work.

3 - GREAT—this is an area that you really did well on.

In this unit, I …	Student	Teacher
identified a set of criteria for a given problem.	**1 2 3**	**1 2 3**
identified a set of constraints for a given problem in a given context.	**1 2 3**	**1 2 3**
considered positive and negative consequences on people when solving a given problem.	**1 2 3**	**1 2 3**
considered positive and negative consequences on the environment when solving a given problem.	**1 2 3**	**1 2 3**
considered how impacts on people and the environment could limit possible solutions.	**1 2 3**	**1 2 3**
used a defined process to evaluate a design solution with respect to both criteria and constraints.	**1 2 3**	**1 2 3**
prioritized criteria and constraints when evaluating design solutions and identified what tradeoffs are made when choosing one design solution over another.	**1 2 3**	**1 2 3**
identified and considered potential stakeholder needs related to each part of the design solution.	**1 2 3**	**1 2 3**

Explain your ratings and how you think you may change or improve your engineering work in the future:

Engineering Self-Assessment Rubric

Category	Beginning 1	Developing 2	Mastery 3
Identify criteria	Describe a given problem.	Describe some criteria for an effective design solution.	Document a complete set of criteria for an effective solution focused on a given problem.
Identify constraints	Describe the context where a given problem is relevant.	Describe some constraints for a given context.	Document a complete set of constraints for an effective solution to a given problem in a given context.
Consequences to people of a design solution	Share ideas for how the problem might impact people.	Describe some of the possible positive and/or negative impacts on people in this problem context.	Document positive and negative consequences on people of solving a given problem, including how some solutions positively impact some while negatively impacting others.
Environmental consequences of a design solution	Share ideas for how the problem might impact the environment.	Describe some of the possible positive and/or negative impacts on the environment in this problem context.	Clearly document positive and negative consequences on the environment of solving a given problem, including how some solutions positively impact parts of the environment while negatively impacting other parts.
Impacts on people and the environment limit possible solutions	Share ideas about how impacts on people and the environment might influence a possible design solution.	Identify and describe how impacts on people and/or the environment might serve as a constraint to possible solutions.	Clearly document how specific impacts on people and/or the environment might serve as a constraint for potential solutions, but these impacts might be prioritized when choosing one solution over another.
Using a defined process to evaluate design solutions	Design solution was **not** evaluated using a design matrix.	Design solution was evaluated using a design matrix that includes **some** criteria and constraints or **non-specific** criteria and constraints.	Design solution was evaluated using a design testing matrix that included **all specific** criteria and constraints. Design solution evaluation includes a full analysis of how well the design will detect, warn, or communicate to people and/or reduce the impact of a tsunami wave.
Prioritizing criteria and constraints and identifying tradeoffs	The criteria and constraints are **not** prioritized.	The criteria and constraints are prioritized in order to produce or evaluate a design solution. There is a rationale for the priority order.	The criteria and constraints are prioritized and weighted in order to produce or evaluate a design solution for use in a particular context. Tradeoffs are identified. There is a clearly stated rationale, including science ideas for the priority and weighing decisions.

Identify and consider the needs of stakeholders	Stakeholders have not been identified, or their needs have not been included in the evaluation process.	Some relevant stakeholders and their needs have been identified and partially included in the evaluation process.	Relevant stakeholders and their needs have been considered and incorporated into the evaluation process.

D. Strategies & Tools for Helping Students Track Ideas Across Lessons

Progress Trackers

The Progress Tracker is a formative and self-assessment tool that is designed to help students keep track of important discoveries that the class makes while investigating the phenomena, and to help them figure out how to prioritize and use those discoveries to focus on explaining the phenomenon they're working on. Students will refer back to the tracker regularly to revise or build on their models, explanations, and/or designs for their current thinking about the phenomenon. Furthermore, students, and the class as a whole, will use the tracker as a way to think with others about what is important in their models, explanations and/or designs.

There are multiple ways to do Progress Trackers in OpenSciEd units. The structure of the Progress Tracker can vary unit to unit, but the most important aspect is that the tool allows students to capture their ideas (in words and pictures) as they develop across the unit.

Examples Progress Trackers:

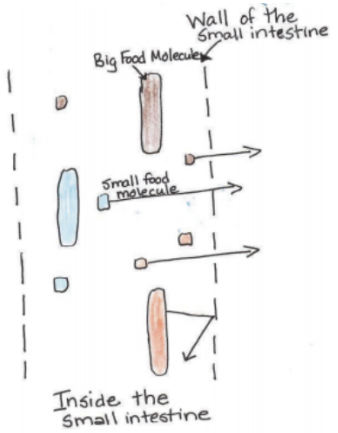
Our Driving Question: How does stuff inside our bodies make us feel the way we do?

Question	What I figured out
1. What's going on with M'Kenna's body that is making her feel the way she does?	Her symptoms seem to be coming from lot's of different parts of her body! Some of the symptoms started first and then others started to come later. I don't really know what's going on, but I have a lot of questions! ----------
----------	
2. Can we see anything inside of M'Kenna that looks different?	MK's small intestine is really smooth compared to a healthy person's small intestine. Is her small intestine causing the problem?

Question	Source of evidence
3. Could food molecules be getting absorbed through the surface of the small intestine?	Dialysis bag experiment Molecular models of starch (big carbohydrate) vs sugar/glucose (small carbohydrate)
What we figured out in words/pictures	

Dialysis tubing is kind of like our small intestine - it's a big tube with holes

When we put big food molecules like starch in the dialysis tubes they are too big to fit through the holes, but smaller food molecules like glucose can fit through. We knew this because the color changed on the outside -detecting the small food molecules, but not the big ones.



Gotta-Have-It Checklists

Instructions: Use your Progress Tracker and your science notebook to add to your checklist the ideas you figured out in the last 2 lessons that you think are important to answer our question.

What our model needs to have to answer the question, "Why do some storms produce hail?"	*Check off pieces of the model as you use them.*	
	Used	*Did not use*
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Use your checklist to make a new model for answering the question. As you use ideas from your checklist, put a check in the "Used" column for the idea and label the concept on your model with its row number from the checklist. If you do not use an idea after all, place a check in the "Did not use" column.

D. Strategies & Tools for Supporting Discussions & Peer Feedback & Teamwork

Self-Evaluation: Engaging in classroom discussions

Setting	Criteria	Absent I do not do this	Developing I occasionally do this (sometimes)	Proficient I often do this	Mastery I consistently do this
In large/whole group settings (Scientist Circle discussions, gallery walks, etc…)	**Shares one's own thinking** by contributing new ideas, questions, and additional clarification.				
	Listens actively to others, rephrasing, repeating and/or reusing the ideas others have shared and asking others to repeat their statements or to clarify ideas when they are difficult to hear or understand.				
	Respectfully provides and receives critiques about explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions.				
	Invites others to share their thinking and contribute their ideas.				
Setting	**Criteria**	**Absent** I do not do this	**Developing** I occasionally do this (sometimes)	**Proficient** I often do this	**Mastery** I consistently do this
In small group settings (partner talk, small group discussions, lab work)	**Shares one's own thinking** by contributing new ideas, questions, and additional clarification.				
	Listens actively to others, rephrasing, repeating and/or reusing the ideas others have shared and asking others to repeat their statements or to clarify ideas when they are difficult to hear or understand.				

	Respectfully provides and receives critiques about explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions.				
	Invites others to share their thinking and contribute their ideas.				

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Peer Feedback Facilitation: A Guide

with Student Guidelines and Rubrics

Teacher Instructions

There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least once, but preferably two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process.

When is a good time to facilitate peer review?

Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work; rather, peer feedback will be more valuable to students if they have time to revise after receiving the peer feedback. It should be a formative, not summative, type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities where they can use these experiences as evidence for their feedback.

What are classroom structures I can use for peer review?

Below are three examples of ways to organize peer review in your classroom. You may choose to use all of them depending on your time or material constraints or you may choose to always use one structure for review so that your students get familiar with it and become better at it over time.

Sticky Note Peer Review: In this protocol - shared on *Tools for Ambitious Science Teaching* - students use sticky notes to leave questions and comments on posted student work. There is time built in for students to respond to feedback. Use the self-assessment rubrics in this document at the end of the class period for students to reflect on their experience in this feedback session.

Peer Review with Unit Rubrics: Each unit and the OpenSciEd curriculum overall have Science and Engineering Practice (SEP) specific rubrics for teachers to assess student work. You can also use these as a way for students to assess each other's work and give feedback on how to improve. For example, in the Sound unit during lesson set one student develops models of how objects vibrate to make sound. They can be assessed with this rubric. We suggest having students use the rubric to give specific feedback to each other. You can use this in a gallery walk type setting or have students exchange models.

Group Review: Ask students to get into groups of four. Have the students bring their individual model or explanation (or other piece of student work to the group). Review feedback guidelines as a class giving examples of good and bad feedback. Then, in pairs, have students provide feedback to the other two pieces of student work. They can use sticky notes or write directly on the work. Make sure to leave individual work time for students to revise their models and complete the self-assessment rubric.

Giving Feedback to Peers

This tool was developed with ideas from the Sticky Note Feedback resource originally developed by Ambitious Science Teaching at: https://ambitiousscienceteaching.org/sticky-note-student-feedback/

Feedback needs to be specific and actionable.

That means it needs to be related to science ideas and provide your own suggestion for improvement.

Productive examples:

- "Your model shows that the sound sources changes position when it is hit. I think you should add detail about how the sound source moves back and forth after it is hit."
- "You said that the drum moves when it makes sound but the table doesn't move when it makes sound. We disagree and suggest reviewing the observation data from the laser investigation."

Nonproductive examples of feedback that do not help other students improve are:

- "I like your drawing."
- "Your poster is really pretty."
- "I agree with everything you said."

How to Give Feedback:

Your feedback should give ideas for specific changes or additions the person or group can make. Use the sentence starters below if you need help writing feedback.

- The poster said _____. We disagree because _____. We think you should change _____.

- I like how you _____. It would be more complete if you added _____.
- We agree that _____. We think you should add more evidence from the _____ investigation.
- We agree/disagree with your claim that _____. However we do not think the _____(evidence) you used matches your claim.

Receiving Feedback from Peers

The purpose of feedback is to get ideas from your peers about things you might improve or change to make your work more clear, more accurate, or better supported by evidence you have collected or to communicate your ideas more effectively to others.
When you receive feedback, you should:

- Read it carefully, ask someone else to help you understand it, if needed.
- Decide if you agree or disagree with the feedback and say why you agree or disagree.
- Revise your work to address the feedback.

Self Assessment: Giving Feedback

How well did you give feedback today?

Today, I…	YES	NO
Gave feedback that was **specific** and about **science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

One thing I can do better next time when I give feedback is:

Self Assessment: Receiving Feedback

How well did you receive feedback today?

Today, I…	YES	NO
Read the feedback I received carefully		
Asked follow up questions to better understand the feedback I received		
Said or wrote why I agreed or disagreed with the feedback		
Revised my work based on the feedback		

What is one piece of feedback you received?_____

What did you add or change to address this feedback? _____

Teamwork Self-Assessment

While working with my team ...		Not today	Once or twice	Several times
I participated in the work.	I shared my thinking and contributed ideas to our design.			
	I used evidence to support my ideas, asked for evidence from others, and/or suggested ways to get additional evidence.			
	I used our time well and helped us stay on task.			
	I contributed to the work of drawing, writing, and building.			
I made sure that my	I monitored my own time spent talking, drawing, writing, building, and/or leading so that others also had a chance to participate in the work.			

teammates were included in the work.	I asked questions to help us understand everyone's ideas.			
	I encouraged others to share their ideas.			
	I provided support and genuine encouragement.			
I kept an attitude that was helpful to problem solving.	I came prepared to work toward a common goal.			
	I was open to changing my mind and challenged myself to think in new ways.			
	I may have critiqued the *ideas* we were working with, but I was careful not to critique the *people* I was working with.			
	When things did not go how we had planned or hoped, I stuck with it and learned from our failures.			

Something I did that I was really proud of during this work was ... (because ...)The hardest part about this work was ... (because ...)

Productive Talk Goals and Moves

Goal One: Help individual students share, expand, and clarify their own thinking	**Observations**
1. **Time to think:** Partner talk; writing as think time; wait time	
2. **Say more**: "Can you say more?"; "What do you mean by that?"; "Give an example"	
3. **So, are you saying…?**: "So, let me see if I've got what you're saying. Are you saying…?" (always leaving space for the original student to agree or disagree and say more)	
Goal Two: Help students listen carefully to one another	

4. **Who can rephrase or repeat?**: "Who can repeat what Javon just said or put it into their own words?" (After a partner talk) "What did your partner say?"	
Goal Three: Help students deepen their reasoning	
5. **Asking for evidence or reasoning**: "Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?"	
6. **Challenge or Counterexample**: "Does it always work that way?" "How does that idea square with Sonia's example?" "What if it had been a copper cube instead?	
Goal Four: Help students think with others	
7. **Agree/Disagree and Why?**: "Do you agree/disagree? (And why?)" "What do people think about what Ian said?" "Does anyone want to respond to that idea?"	
8. **Add On**: "Who can add onto the idea that Jamal is building?" "Can anyone take that suggestion and push it a little further?"	
9. **Explaining What Someone Else Means**: "Who can explain what Aisha means when she says that?" "Why do you think he said that?"	

E. Instructional Strategies for Writing and Drawing

Writing and Drawing Strategies	Observations
1. ***Audience and Purpose:*** Introduce a specific audience and consider the purpose for the writing and drawing.	
2. ***Choice:*** Provide students with opportunities to make personal choices about what or how to write or draw.	
3. ***Characteristics:*** Discuss or identify characteristics/structure of a specific form of writing or drawing (e.g. an argument includes CER).	

4. ***Talk out loud:*** Have students say out loud their ideas before writing and drawing (either to themselves or others).	
5. ***Evaluate Examples:*** Examine examples (student generated or provided) to jointly establish an understanding of key characteristics, identify similarities & differences or evaluate strengths & weaknesses.	
6. ***Select from options.*** Provide different options (e.g. different claims, different ways to draw part of a model) and ask students to select the best option to use in their writing or drawing.	
7. ***Graphic Organizer:*** Use a graphic organizer or template to help students organize their ideas to inform their writing or drawing.	
8. ***Sentence Stems/Image Starters:*** Provide sentence stems or image starters to help students start writing and drawing.	
9. ***Checklist:*** Have students use a checklist to determine whether the goals were met in writing or drawing.	
10. ***Work together:*** Have students work together to plan and to engage in writing or drawing (e.g. small group model).	
11. ***Self-evaluate:*** Have students self-evaluate and/or revise their writing and drawing with specific goals or questions.	
12. ***Provide feedback.*** Teachers or peers provide specific feedback including strengths in writing and drawing to support revision.	

Strategies adapted from Graham, MacArthur & Hebert (2019). *Best Practices in Writing Instruction*. New York, NY: The Guildford Press.

F. Navigation Ideas

OpenSciEd Units embed navigation moves at the beginning, middle and end of lessons, but you may choose to modify how you navigate through a unit. Below are a list of general ideas that you can use and modify to change up your navigation routine.

Ideas for Navigation Moves

- Use the DQB--If we answer this group of questions, how could this help our thinking?
- Use a gap in the model/problematizing move-- why do we need to figure out __? What parts of this system do we / did we still have questions about?
- Use a broadening/generalize move-- why would testing more things help us? Do we think this relationship holds true in all cases?
- Motivate the next investigation--why/how would doing this next investigation help us?
- How could we use this tool (or what would we look for in this data) to help make progress on our question?
- Use the progress tracker at the beginning of a lesson to think through what did we just figure out and motivate the next question
- To summarize/distill complex ideas - what's the main takeaway that we figured out?
- Use exit tickets to capture students' ideas based on what they figured out.

Helpful questions for navigation:

- If we started at _____ [describe the next place to go], how will this help us?
- How can we sum up what we figured out in our last lesson? Or What were the big questions we came up with in the last lesson?
- What resources can we look at to figure out where we landed in the last lesson?
- What type of data would we need to analyze, in order to help answer question X?
- What do you think we should do next to make progress on this question (X)...?
- How could we go about testing these different ideas...? Or How would we measure (X)?
- What would we need to be able to test our predictions...?
- What evidence do we need to collect to figure out whether this is the case or not?
- What could we do to...? Or How could we investigate...? Or How should we keep track of...?

Quick navigation moves for when you run out of time:

- Take 1 minute of silent thinking/writing time to jot down what we figured out last time. Share that with a neighbor (then share out).
- Take 1 minute and summarize what you figured out today. Share with a neighbor.
- Have one or two students state the big ideas figured out in the lesson and what the class is still wondering about.

Navigation Routine Tracker

How do we work with students to motivate the next step in an investigation?

Lesson Question	How did we get here?: From a student's perspective, why did we decide we needed to investigate the lesson question?	What did the teacher do to support navigating us to get here?	From a student's perspective, what do we need to investigate next? (We figured out...BUT...so we decided…)

G. Teacher Tools to Reflect and Plan

Anchoring Phenomenon Routine Tracker

	Element 1: Explore the Phenomenon  *What do we notice?*	**Element 2:** Attempt to Make Sense of the Phenomenon  *How can we explain this? Do our explanations agree?*	**Element 3:** Identify Related Phenomena  *Where else does something similar happen?*	**Element 4:** Develop Questions and Next Steps  *What should we do to figure out how to explain this?*
Notes about what you or the students did.				
How does this support ***figuring out***?				
How does this support a ***classroom culture where all students have access?***				

Discussion Planning and Reflection Tool

Before the discussion (Analyzing and reflecting on the lesson in the teacher guide):

1. What is the question students are trying to answer through this discussion?

2. What is the intended outcome of the discussion? (coming to consensus on something we just experienced? Figuring out improvements to our model? Designing an investigation? Getting students to realize they have new questions?)

3. What are the key elements of the model or explanation you want the students to grapple with? (create an explanatory model for this phenomenon for yourself)

4. What other ideas might students have? What questions might they ask?

B. Leading the Discussion (Considering talk moves and strategies in teacher guide)

1. What will you say to launch the discussion?

2. What are some things you will say to encourage your students to work with one another's ideas?

3. If students seem to think they have explained the phenomenon but you know they need to go deeper, what kinds of questions could you ask to help students see the need to extend or revise their explanations?

4. What will you say to help close the discussion to synthesize what it is you all agree on and/or what new questions you have?

C. Reflection: After the discussion (spend 10-20 quiet minutes writing)

- What ideas and reasoning did you hear? How would you describe the groups' understanding of the ideas you identified in question 3 of your planning?

- What went well in the discussion?

- What was challenging?

- Describe a moment when you weren't sure what to do. What *did* you do and why? And what was the result?

- Anything you would do differently if you could do it over?