

Who Moved the Beach?



Deanna Fioresi – Beach Erosion

Grade Level: 6

Teaching Time: four 50-minute class periods (depending on level of 3D printing knowledge, may need to add an extra day)

NJ Student Learning Standards – Technology & Design

- 8.1.8.A.1 Demonstrate knowledge of a real-world problem using digital tools.
- 8.1.8.A.3 Use and/or develop a simulation that provides an environment to solve a real-world problem or theory.
- 8.1.8.A.4 Graph and calculate data within a spreadsheet and present a summary of the results
- 8.1.8.F.1 Explore a local issue, by using digital tools to collect and analyze data to identify a solution and make an informed decision.
- 8.2.8.A.4 Redesign an existing product that impacts the environment to lessen its impact(s) on the environment.
- 8.2.8.B.1 Evaluate the history and impact of sustainability on the development of a designed product or system over time and present results to peers.
- 8.2.8.C.1 Explain how different teams/groups can contribute to the overall design of a product.
- 8.2.8.C.4 Identify the steps in the design process that would be used to solve a designated problem.
- 8.2.8.D.1 Design and create a product that addresses a real-world problem using a design process under specific constraints.
- 8.2.8.D.3 Build a prototype that meets a STEM-based design challenge using science, engineering, and math principles that validate a solution.

NJ Student Learning Standards – Mathematics

- Grade 6: 5. Use appropriate tools strategically.
- Grade 6: 6. Attend to precision.

NJ Student Learning Standards – Science / NGSS

- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-LS2-1 Ecosystems: Interactions, Energy and Dynamics

Learning Objectives:

1. Students will *define* coastal erosion as a natural process and *explain* how human activity can increase the risks associated with coastal erosion. (MS-LS2-1, Tech 8.1.8.A.1, Tech 8.1.8.F.1)
2. Students will *identify* options for reducing risks caused by coastal erosion, and *discuss* the advantages and problems associated with these options. (MS-LS2-1)
3. Students will *analyze* and *interpret* beach elevation data and make inferences from these data about the relative vulnerability of different beaches to coastal erosion. (MS-ETS1-3, Math 6:5, Tech 8.1.8.A.4)
4. Students will *research* various barriers used to help protect the beaches and use the design process to *design* and 3D print their own barrier. (MS-ETS1-2, Math 6:6, Tech 8.1.8.A.3-4, 8.2.8.B.1, 8.2.8.C.1 & 4, 8.2.8.D.1 & 3)

Driving Question:

How can human communities respond to the processes of erosion so that they are sustainable for the environment?

Justification:

Living 45 minutes away from the Jersey shore, beach erosion covers our nightly news. My students spend a lot of their summer days at the beach and I'm sure this assignment will grab their attention. Many of their parents own property along the areas mentioned in the data set. I will teach this lesson as a research and design unit. In this lesson, students will research and discuss how coastal erosion occurs. They will then analyze data on the annual shoreline position from the year 1994 to 2016 and chart the data, analyzing the charts for understanding. Next, we would research barriers that have been used to try to save our beaches. We would then plan and design our own beach protection barriers on TinkerCad and print 3D prototypes to be tested in a simulated environment.

This lesson connects to science by discussing weather and phenomena. Students will be shown images of coastal erosion in NJ on the projector and will engage in whole class discussion of how severe weather changes our shoreline. This lesson connects to ocean life and ecosystems through students defining coastal erosion as a natural process that effects all shore life and explaining how human activity can increase the risks associated with coastal erosion.

This lesson connects to math by analyzing the overall volume change of their chosen county's shoreline in cubic yards per foot. It will also connect to math by graphing the data using spreadsheet software. Student groups will present their graphs to the class and we will discuss which beach profile has had the most change, which beach might be the most resistant to wave erosion, which beach might be the most vulnerable and

discuss the three main options for responding to erosion threats discussed in the previous worksheet (leave, renourish or rebuild).

This lesson connects to technology by using the Internet to complete the “Who Moved the Beach?” worksheet, to create a spreadsheet of the changes in beach profiles, to research beach protection barriers already in place that protect our beaches and to use 3D printing software to design their own beach protection barrier.

This lesson connects to engineering by using the design process to design a beach protection barrier prototype. Students will complete a STEM journal that will describe their thought process throughout this journey (Defining the problem, making a plan, listing materials, what worked/didn't work, reflect and adjust).

By using data that can tie several subject areas together, students will understand that their core subject classes ultimately work as one to build their problem-solving skills to prepare them for their future. Students will gain interest in beach erosion through pictures, videos and discussion of how weather effects the beaches. They will expand on that knowledge through vocabulary, analysis and research, with the end result of creating a new product that could ultimately help with beach erosion.

While looking for a data source of interest to me and my students, I stumbled upon a lesson plan developed by the US Department of Commerce, & National Oceanic and Atmospheric Administration titled “Who Moved the Beach?” This caught my attention immediately and I wanted to explore the lesson and expand it into a unit for my middle schoolers. (NOAA, 2008)

https://oceanservice.noaa.gov/education/lessons/who_moved_the_beach.html

Prior Knowledge:

Living in New Jersey, my students frequent the Jersey shore a lot during the summer months and a lot during the off-peak season. The cities along the shoreline are growing with homes and businesses. Recently, New Jersey has been hit by many winter and tropical storms resulting in families losing their homes and businesses having to start over. My students have seen the towns that have been devastated from these storms. They are also aware of the effort and money that goes into replenishing the beaches as it overwhelms the news. In this lesson, students will learn about the major causes and impacts of coastal erosion and will use elevation data to construct profiles of three beaches and make inferences about erosion processes on these beaches.

Vocabulary:

Accretion
Erosion
Dune
Berm

Beach profile
Sea walls
Jetties
Bulkheads

Materials List:

Computer with internet capability to access websites located throughout the lesson plan.

optional: projector

“Who Moved the Beach” Student worksheet

Google Sheets, MS Excel or equivalent

STEM journal/planning sheet

Knowledge of Tinkercad.com software (could also use recyclable materials to create prototypes if 3D printing isn't available)

Plastic container, sand, water and other misc. material to test prototypes

Day 1

Engage:

1. Teacher will show news footage of Hurricane Sandy's impact on the jersey shore. <https://www.youtube.com/watch?v=Qtqhz-twPNA>
 - a. Think about how these businesses have been impacted. What would you do if you were a business owner?
 - b. Think about how many lives were in danger. Who is there to help?
 - c. Could any barrier have helped prevent this damage?
 - d. Who helps with clean up?
(These questions are used to get the students thinking about the impact a major storm has on the coastline.)
2. Now, teacher will show three images displayed on the board of storm damage after math. On a piece of paper, students will jot down their thoughts about the images based on the following questions: (*formative assessment*)
 - a. Have you seen images like these in real life before?
 - b. What could have caused this?
 - c. Is it important?
 - d. What can humans do to help?



Beach erosion at Nuns' Beach in Stone Harbor.

Wind and tides, not snowfall, the big problems on the Jersey Shore: Down the Shore. (n.d.). Retrieved from <https://why.org/articles/wind-and-tides-not-snowfall-the-big-problems-on-the-jersey-shore/>



North Wildwood beach erosion.

Tomczuk, J. (2017, March 15). South Jersey shore towns assess beach erosion after nor'easter. Retrieved from https://www.pressofatlanticcity.com/news/south-jersey-shore-towns-assess-beach-erosion-after-nor-easter/article_3c6fd791-597a-5394-89d6-297859f65b84.html



A 2-to-3-foot cliff shows signs of erosion at the 82nd Street beach in Long Beach Township.

Lazarus, I. (2010, February 08). Many Jersey Shore beaches get hit hard by weekend storm. Retrieved from <http://findashorehome.com/2010/02/08/jersey-shore-beaches-hit-hard-weekend-storm/>

3. On a large piece of butcher paper posted on the board, create a KWL chart. (*formative assessment*) Students will take turns writing ideas on the board about what they know and what they want to know about erosion.
 - a. Discuss: While **erosion** and **land subsidence** (land sinking below sea level), are less spectacular than strong storms, they are just as important in economic terms. Erosion alone is estimated to cause billions of dollars of damage every year along U.S. coasts.
 - b. Attempts to protect against coastal hazards can cause additional problems. **Sea walls** intended to protect against storm waves can actually accelerate beach erosion and reduce the capacity of beaches to absorb storm energy. As a result, buildings adjacent to the beaches are exposed to the full force of wind and waves. Experience has shown that prevention is the best approach to deal with these problems. It costs much less to prevent construction in areas unsuitable for development than to provide funds for emergency response, cleanup, and reconstruction. NOAA's Office of Ocean and Coastal Resource Management works in partnership with state governments to minimize the impact of coastal hazards by
 - i. Identifying areas that are most likely to be severely affected by these hazards;
 - ii. Developing warning systems and response plans to minimize human exposure to hazardous events;
 - iii. Establishing appropriate building codes; and
 - iv. Restoring the natural protective functions of beaches and dunes. (NOAA, 2008)
4. Ask students for a show of hands of who has witnessed beach erosion during their trips to the shore. In what ways? (*formative assessment*)
5. Show news clip <http://6abc.com/weather/storm-brings-beach-erosion-flooding-at-jersey-shore/1013388/> of coastal erosion caused by severe weather by projecting

onto the white board and answer a quick Google Form to check for understanding. (*formative assessment*)

- a. Are the beaches protecting the property? In what way?
- b. What caused the beach erosion?
- c. How much money will it take to fix the beach?
- d. What kind of barriers do the business owners and home owners use?

Explore:

6. Part 1: Students will work in groups to learn about the coastal erosion process by completing the “Who Moved the Beach Student Worksheet” provided by NOAA (2008). Worksheet and answer key are below lesson plan. Discuss answers as a class and complete the “L” section on the KWL chart on the board. (*worksheet=summative assessment, KWL=formative assessment*)

Day 2

1. Complete “Who Moved the Beach Student Worksheet” if not complete. If complete, review yesterday’s lesson by asking students:
 - a. What is erosion?
 - b. What causes erosion?
 - c. Why should we try to protect our beaches?
2. Part 2: In groups, students will choose a county in New Jersey (Monmouth, Ocean, Atlantic or Cape May) to analyze the overall volume change in cubic yards per foot, found in the Appendix beginning on page 198 of the article “An Analysis of Thirty Years’ Study of Sand Redistribution and Shoreline Changes in New Jersey’s Four Coastal Counties”. <https://www.stockton.edu/coastal-research-center/njbpn/documents/reports/CapeMayCo2016.pdf> Each survey site has data on the annual shoreline position from the year 1994 to 2016. After reading the data set, students will enter the survey sites’ overall shoreline changes in a spreadsheet and create a chart to visually show which site has encountered the most erosion. (*walk around to assess progress and understanding=formative assessment, completed graph/presentation=summative assessment. Rubric below lesson plan.*)
 - a. Choose a NJ county to analyze.
 - b. Open the link above and navigate to page 198 of the article.
 - c. Find your county of choice.
 - d. In another tab, open a blank spreadsheet.
 - e. Insert the data (profile site location and overall change) into the spreadsheet.
 - f. Create a line graph to show the overall changes throughout the county.

Explain:

3. Teacher will facilitate a discussion of students’ beach profiles. Students will show their charts on the projector and compare their findings with other groups.

4. Ask students to infer which of the beaches analyzed might be most vulnerable to wave erosion. Why?
5. Ask students what sorts of beach profiles might be most resistant to wave erosion. Why?
6. Discuss the three options for responding to erosion threats listed in the last question on the worksheet: **leave, renourish or rebuild**.
 - a. Students should realize that while leaving may be the least expensive option, this is often impractical where development has already taken place.
 - b. Renourishment, however, is seldom a permanent solution. Similarly, various construction options can make property more resistant to erosion, but structures such as **sea walls, jetties, and bulkheads** often increase erosion and shift the problem to other areas by interrupting the natural flow of sand. (NOAA, 2008)

Days 3 & 4

Elaborate/Extend:

1. Class Discussion: Many people who live in erosion-prone areas believe that they have the right to take whatever steps are necessary to protect their property from erosion. For example, a 1998 report in the Maryland Law Review points out that more and more houses are being built just inland of sandy beaches that are generally considered to be public lands. Because sea level is rising and most shores are eroding, the ocean will eventually reach these houses unless the houses are moved or the sea is held back. The most common “solution” is to build a wall between the private dry land and the public beach. The result is that the private land is saved and the beach erodes away. In Maryland alone, more than three hundred miles of tidal shoreline have been “armored” in the last 20 years. (NOAA, 2008)
2. Using the projector, explore these websites as a class to discover how the government is trying to preserve our shoreline.
http://www.beachapedia.org/Shoreline_Structures
<http://www.state.nj.us/dep/shoreprotection/>
<http://explorebeaches.msi.ucsb.edu/>
<https://oceanservice.noaa.gov/hazards/natural-hazards/>
3. Have students get into their groups from yesterday.
 - a. What other ideas can your group come up with to save the beaches?
 - b. Using the design process, create an idea that could be used to help prevent beach erosion. Be sure to use the STEM planning journal to guide your group. (*Formative Assessment*)
 - c. Once you have sketched your plan, use TinkerCad.com to create a prototype. (If 3D printing isn't available, could also create a prototype out of recyclable material.)

- d. We will print the prototypes and use other everyday items to create a simulation of a beach with strong rain and winds (long container, sand, water, rocks, fan, etc.) to test the ideas. (*Summative Assessment. Rubric below lesson plan.*)

Evaluate:

1. Formal Assessment: Student responses to questions about images in the Engaging section of the lesson will help teacher understand students' prior knowledge about beach erosion.
2. Students will define coastal erosion as a natural process and explain how human activity can increase the risks associated with coastal erosion.
 - a. Summative Assessment: Evaluated by completion of the fill in the blank student worksheet. Answer key is provided below.
 - b. Formal Assessment: KWL chart will help teacher to guide student learning by assessing what they already know, what they want to know and ultimately, what they learned.
 - c. Formative Assessment: Student examples of when they have witnessed erosion will show that they understand what erosion is.
3. Students will identify options for reducing risks caused by coastal erosion, and discuss the advantages and problems associated with these options.
 - a. Summative Assessment: Evaluated by completion of the fill in the blank student worksheet. Answer key is provided below.
 - b. Formative Assessment: Google Form for a quick check to ensure students understood the information presented in the news clip.
4. Students will analyze and interpret beach elevation data and make inferences from these data about the relative vulnerability of different beaches to coastal erosion.
 - a. Summative Assessment: Evaluated by the completion of the charted data of beach erosion and being able to explain the results (rubric provided).
 - b. Formative Assessment: Walk around to each group to check for understanding of data analysis, graph completion and interpretation.
5. Students will research various barriers used to help protect the beaches and use the design process to design and 3D print their own barrier.
 - a. Summative Assessment: Evaluation will be based on the students' beach erosion protection/barrier (rubric provided).
 - b. Formative Assessment: STEM journal is completed to show that students understand the design process.

Who Moved the Beach? Student Worksheet

The following reports and articles contain the information needed to complete this worksheet:

“Evaluation of Erosion Hazards” prepared by the H. John Heinz III Center for Science, Economics and the Environment (summary report) <http://heinzhome.heinzctrinfo.net/publications/PDF/erosnsum.pdf#zoom=100>

“Coastal Change Hazards” U.S.G.S. Web site beginning at: <http://coastal.er.usgs.gov/hurricanes/cch.html>

“Coastal Erosion: Where’s the Beach?” Bridge Data Tip at: <http://www.vims.edu/bridge/archive0500.html>

“Beaches on the Brink” CNNfyi.com article at <http://archives.cnn.com/2000/fyi/news/09/20/coastal.erosion/index.html>

1. Beach sand originates mainly from _____, and also comes from _____, and from _____.
2. Coastal erosion is a natural process that removes sediment from shorelines. Another natural process that deposits sediment on shorelines is known as _____.
3. Sand is generally moved offshore by high-energy waves during _____ months, and is returned by gentle waves during _____ months.
4. Movement of sand parallel to the coast by wave action, wind, and currents is known as _____.
5. Sea walls, jetties, and bulkheads may contribute to erosion because _____.
6. The _____ or _____ (if there is no dune present) are the “first line of defense” against coastal erosion from wind and waves.
7. _____ are composed primarily of sand and are the most dynamic land masses along the open-ocean coast.
8. The impact of a storm on a barrier island is dependent on storm characteristics and the _____ of the barrier island when the storm makes landfall.
9. The Coastal Change Hazard Scale categorizes net erosion during storms into _____ impact levels or “regimes.”
10. In the _____ Regime, waves cross the base of dunes, causing erosion and semi-permanent changes.

11. In the _____ Regime, storm waves are high enough to completely submerge the island, allowing sand to be transported over a distance of one or more kilometers toward the mainland.
12. In the _____ Regime, waves exceed the elevation of the dune or beach berm (if no dune is present), causing sand to be transported toward the mainland so the barrier island “migrates” landward.
13. In the _____ Regime, waves are confined to the beach. Sand may move offshore, but will be eventually returned so there is no net erosion.
14. Over the next 60 years, erosion may claim _____ of every _____ houses within 500 feet of the U.S. shoreline.
15. Most of the damage from erosion over the next 60 years will occur in low-lying areas that also have the highest risk from _____.
16. When the Cape Hatteras lighthouse was constructed in 1870, it was _____ feet from the shore. By 1987, the lighthouse was _____ feet from the sea due to coastal erosion.
17. About 87,000 homes are located on low-lying land or bluffs that are likely to erode into the ocean or the Great Lakes over the next 60 years.
18. Without additional beach nourishment or structural protection, roughly _____ homes and the land on which they are built will be lost to erosion each year.
19. The average annual erosion rate along the Atlantic coast is about _____ feet.
20. The highest erosion rates in the United States are in coastal areas bordering _____.
21. A major storm can erode the coast inland _____ feet or more in a single day.
22. The _____ coast has the largest number of structures located within the 60-year erosion hazard area.
23. Ecological concerns related to erosion arise primarily because of the scarcity of _____.
24. Coastal erosion may increase during the next 50 to 100 years if polar ice caps melt and cause a rise in _____.
25. People have three choices when erosion poses a threat: _____, _____, or _____.

Who Moved the Beach?

Student Worksheet Answer Key

1. Beach sand originates mainly from rivers and streams, and also comes from weathering of exposed rock formations, and from the deterioration of shells, corals, and skeletal fragments.
2. Coastal erosion is a natural process that removes sediment from shorelines. Another natural process that deposits sediment on shorelines is known as accretion.
3. Sand is generally moved offshore by high-energy waves during winter months, and is returned by gentle waves during summer months.
4. Movement of sand parallel to the coast by wave action, wind, and currents is known as longshore transport.
5. Sea walls, jetties, and bulkheads may contribute to erosion because they affect natural water currents and prevent sand from shifting along coastlines to replenish beaches.
6. The first dune ridge or beach berm (if there is no dune present) are the “first line of defense” against coastal erosion from wind and waves.
7. Barrier islands are composed primarily of sand and are the most dynamic land masses along the open-ocean coast.
8. The impact of a storm on a barrier island is dependent on storm characteristics and the elevation of the barrier island when the storm makes landfall.
9. The Coastal Change Hazard Scale categorizes net erosion during storms into four impact levels or “regimes.”
10. In the Collision Regime, waves cross the base of dunes, causing erosion and semi-permanent changes.
11. In the Inundation Regime, storm waves are high enough to completely submerge the island, allowing sand to be transported over a distance of one or more kilometers toward the mainland.
12. In the Overwash Regime, waves exceed the elevation of the dune or beach berm (if no dune is present), causing sand to be transported toward the mainland so the barrier island “migrates” landward.
13. In the Swash Regime, waves are confined to the beach. Sand may move offshore, but will be eventually returned so there is no net erosion.

14. Over the next 60 years, erosion may claim one of every four houses within 500 feet of the U.S. shoreline. (According to a study by the H. John Heinz III Center for Science, Economics and the Environment; see "Resources")
15. Most of the damage from erosion over the next 60 years will occur in low-lying areas that also have the highest risk from flooding.
16. When the Cape Hatteras lighthouse was constructed in 1870, it was 1,500 feet from the shore. By 1987, the lighthouse was 160 feet from the sea due to coastal erosion.
17. About 87,000 homes are located on low-lying land or bluffs that are likely to erode into the ocean or the Great Lakes over the next 60 years.
18. Without additional beach nourishment or structural protection, roughly 1,500 homes and the land on which they are built will be lost to erosion each year. (According to a study by the H. John Heinz III Center for Science, Economics and the Environment; see "Resources.")
19. The average annual erosion rate along the Atlantic coast is about 2 to 3 feet.
20. The highest erosion rates in the United States are in coastal areas bordering the Gulf of Mexico.
21. A major storm can erode the coast inland 100 feet or more in a single day.
22. The Atlantic coast has the largest number of structures located within the 60-year erosion hazard area.
23. Ecological concerns related to erosion arise primarily because of the scarcity of wetlands.
24. Coastal erosion may increase during the next 50 to 100 years if polar ice caps melt and cause a rise in sea levels.
25. People have three choices when erosion poses a threat: leave, renourish, or build.

Who Moved the Beach? Chart Rubric Student Name:

CATEGORY	4	3	2	1
Title	Title is creative and clearly relates to the problem being graphed (includes dependent and independent variable). It is printed at the top of the graph.	Title clearly relates to the problem being graphed (includes dependent and independent variable) and is printed at the top of the graph.	A title is present at the top of the graph.	A title is not present.
Data Table	Data in the table is well organized, accurate, and easy to read.	Data in the table is organized, accurate, and easy to read.	Data in the table is accurate and easy to read.	Data in the table is not accurate and/or cannot be read.
Labeling of X axis	The X axis has a clear, neat label that describes the units used for the independent variable (e.g., days, months, participants' names).	The X axis has a clear label that describes the units used for the independent variable.	The X axis has a label.	The X axis is not labeled.
Labeling of Y axis	The Y axis has a clear, neat label that describes the units and the dependent variable (e.g., % of dogfood eaten; degree of satisfaction).	The Y axis has a clear label that describes the units and the dependent variable (e.g., % of dogfood eaten; degree of satisfaction).	The Y axis has a label.	The Y axis is not labeled.
Type of Graph Chosen	Graph fits the data well and makes it easy to interpret.	Graph is adequate and does not distort the data, but interpretation of the data is somewhat difficult.	Graph distorts the data somewhat and interpretation of the data is somewhat difficult.	Graph seriously distorts the data making interpretation almost impossible.
Neatness and Attractiveness	Exceptionally well designed, neat, and attractive. Colors that go well together are used to make the graph more readable. A ruler and graph paper (or graphing computer program) are used.	Neat and relatively attractive. A ruler and graph paper (or graphing computer program) are used to make the graph more readable.	Lines are neatly drawn but the graph appears quite plain.	Appears messy and \"thrown together\" in a hurry. Lines are visibly crooked.

STEM CHALLENGE DATA & RESULTS

TODAY MY CHALLENGE IS:

WHAT PROBLEM DO I NEED TO SOLVE?

WHAT SUPPLIES WILL I USE?

WHAT IS MY PLAN?

WHAT WORKED FOR ME?

WHAT DID NOT WORK FOR ME ?

Who Moved the Beach? Design Rubric Student Name:

CATEGORY	4	3	2	1
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.
Information Gathering	Accurate information taken from several sources in a systematic manner.	Accurate information taken from a couple of sources in a systematic manner.	Accurate information taken from a couple of sources but not systematically.	Information taken from only one source and/or information not accurate.
Construction - Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.
Journal/Log - Content	Journal provides a complete record of planning, construction, testing, modifications, reasons for modifications, and some reflection about the strategies used and the results.	Journal provides a complete record of planning, construction, testing, modifications, and reasons for modifications.	Journal provides quite a bit of detail about planning, construction, testing, modifications, and reasons for modifications.	Journal provides very little detail about several aspects of the planning, construction, and testing process.

Modification/Testing	Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles.	Clear evidence of troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence of troubleshooting, testing or refinement.
Function	Structure functions extraordinarily well, holding up under atypical stresses.	Structure functions well, holding up under typical stresses.	Structure functions pretty well, but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Scientific Knowledge	Explanations by all group members indicate a clear and accurate understanding of scientific principles underlying the construction and modifications.	Explanations by all group members indicate a relatively accurate understanding of scientific principles underlying the construction and modifications.	Explanations by most group members indicate relatively accurate understanding of scientific principles underlying the construction and modifications.	Explanations by several members of the group do not illustrate much understanding of scientific principles underlying the construction and modifications.

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