Which food requires the most water to produce?

<table>
<thead>
<tr>
<th>0.45 kg (1 lb) of beef</th>
<th>0.45 kg (1 lb) of potatoes</th>
<th>0.45 kg (1 lb) of chicken</th>
</tr>
</thead>
</table>

| 1 loaf of bread | 3.8 L (1 gal) of milk | 0.45 kg (1 lb) of almonds |

Smithsonian Science Education Center
## Water Footprint of Common Food Sources

<table>
<thead>
<tr>
<th>Food Source</th>
<th>Weight</th>
<th>Water Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>0.45 kg</td>
<td>6,813 L (1,800 gal)</td>
</tr>
<tr>
<td>Potatoes</td>
<td>0.45 kg</td>
<td>450 L (119 gal)</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.45 kg</td>
<td>1,771 L (468 gal)</td>
</tr>
<tr>
<td>Bread</td>
<td>1 loaf</td>
<td>908 L (240 gal)</td>
</tr>
<tr>
<td>Milk</td>
<td>3.8 L</td>
<td>3,331 L (880 gal)</td>
</tr>
<tr>
<td>Almonds</td>
<td>0.45 kg</td>
<td>7,570 L (2,000 gal)</td>
</tr>
</tbody>
</table>

*Image credit: Smithsonian Institution*
What does high quality science teaching and learning look like?

*Using Real-World Problems to Drive Student Learning Through Integrated Hands-On and Digital Experiences*

Dr. Carol O’Donnell
Executive Director, Smithsonian Science Education Center
The Smithsonian is the world’s largest museum, education, and research complex with 19 museums, 5 education centers, 9 research centers, a zoo, with 138 million objects, artworks, and specimens in its collection.
The Smithsonian believes in lifelong experiential learning.
Smithsonian Science Education Center

Transforming K-12 *Education through Science®* in collaboration with communities across the globe

Founded in 1985

Renamed in 2013
Agenda

- Engage in an Example of High Quality Science Teaching and Learning
- Reflect on the Example: Process Standards, Tools to Know, Ways to Show
- Examine Data that Proves This Works
Engage in an Example of High Quality Science Teaching and Learning
Knowledge & Skills Statements: The Earth Consists of Useful Resources and Its Surface is Constantly Changing

- Where does the water you need come from?
- How have humans impacted the water we need?
- How do we solve the problem of moving freshwater from where we have it, to where we need it?
- How can we provide freshwater to those in need?
What do you notice?

List everything you notice.

Name the phenomenon if you know it.

What do you wonder?

List why you think this happened.

List all of the questions you have.
What is the scientific phenomenon?

What do you notice?  What do you wonder?
What is the scientific phenomenon? (6:20-6:48)

1. https://www.youtube.com/watch?v=x3mcYaQYtMk

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Knowledge & Skills Statements: The Earth Consists of Useful Resources and Its Surface is Constantly Changing

- Where does the water you need come from?
- How have humans impacted the water we need?
- How do we solve the problem of moving freshwater from where we have it, to where we need it?
- How can we provide freshwater to those in need?
Design (engineer) a solution for pumping groundwater to the surface.

A full body of groundwater is called an aquifer.
The Edwards Aquifer in Texas
Water Pump: Lesson 5

Criteria (goals)

- Pump at least 50 mL of water from the floor to the desktop.
- The water must travel from one beaker on the floor through 5 lengths of airline tubing, to the other beaker on the desktop.

Constraints (limits)

- Move only the syringe and the three-way valve during testing.
Test 1

Draw a diagram of your design

Amount of water moved: ______________mL

Difficulties:

Test 2

What did you modify?

Amount of water moved: ______________mL

Difficulties:

Controls:

These two tests were/were not a fair test because
Knowledge & Skills Statements: The Earth Consists of Useful Resources and Its Surface is Constantly Changing

- Where does the water you need come from?
- How have humans impacted the water we need?
- How do we solve the problem of moving freshwater from where we have it, to where we need it?
- How can we provide freshwater to those in need? (using technology to address water scarcity and water equity)
Aquation: Freshwater Simulation

Aquation is a strategy game in which you must manage the world’s water and wealth to make sure that everyone on Earth has enough freshwater to meet their needs.

Win the Game: Redistribute Earth’s freshwater so that every region has the amount of water it needs.

Basic Gameplay:

Groundwater
- Tan regions need more water.
- Blue regions have the most water.

Wealth
- Build a pipeline between regions
- Transfer water
- Build a desalination plant
- Purify water using a desalination plant

Make sure every region has enough water to win the game!
Assessment: Design Challenge “Get it, Treat it, Share it”

Scenario: Your town is running out of water! There has been a drought for four years and your town has key stakeholders in agriculture, industry, housing and the environment that must work together to purchase supplies to pump the water up from underground, treat the water, and then develop a plan to allocate the water to where it is needed. You will be given a stakeholder role and a minimum water requirement. Each group will be given $100 to buy supplies. To successfully supply your town with the water it needs, you must work together, compromise, and search for ways to improve your design and allocation plan. Good luck!
<table>
<thead>
<tr>
<th>Concepts and Practices</th>
<th>Indicators of Success</th>
<th>Indicators of Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.</td>
<td>□ Students observe and discuss how the three-way valve works before figuring out how to incorporate it into the solution. Students use data from the first test in order to inform design changes.</td>
<td>□ Students make design decisions without considering evidence from the first test.</td>
</tr>
<tr>
<td>At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.</td>
<td>□ Students share proposed solutions to failure points. Students apply ideas heard during class discussion to inform design changes.</td>
<td>□ Students do not share proposed solutions to failure points and do not apply ideas heard in class to inform design changes.</td>
</tr>
<tr>
<td>Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.</td>
<td>□ Students identify and share failure points with the class.</td>
<td>□ Students do not identify or share failure points in their design with the class.</td>
</tr>
<tr>
<td>Designing solutions</td>
<td>□ Students use evidence from the first test to redesign a solution to the problem of moving water from the floor to the desk.</td>
<td>□ Students do not use evidence from the first test while redesigning their solution to the problem of moving water from the floor to the desk.</td>
</tr>
<tr>
<td>Structure and function</td>
<td>□ Students observe the structure of the three-way valve in order to determine its function.</td>
<td>□ Students do not figure out the function of the three-way valve.</td>
</tr>
<tr>
<td>System and system models</td>
<td>□ Students discuss how changing one failure point will impact the entire system.</td>
<td>□ Students suggest the only way to change the entire system is to change every aspect of the system.</td>
</tr>
<tr>
<td>Cause and effect</td>
<td>□ Students identify a direct cause-and-effect relationship between their improvement and overall output of the system.</td>
<td>□ Students do not identify a direct cause-and-effect relationship between their improvement and overall output of the system.</td>
</tr>
</tbody>
</table>
Reflect on the Example: Process Standards, Tools to Know, Ways to Show
TEKS Standards

• Process Standards
• Tools to Know
• Ways to Show
• Knowledge and Skills Statements

3-Dimensional Learning

• Science and Engineering Practices
• Cross-cutting Concepts
• Disciplinary Core Ideas
What *Phenomena* In Science and Engineering did we observe?

- Natural phenomena are observable events that **have causes**, occur in the universe, and that we can use our science knowledge to explain or predict. The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena.

- Engineering involves designing solutions to problems that arise from phenomena, and using explanations of phenomena to design solutions.

- In this way, phenomena are the context for the work of both the scientist and the engineer.
What Scientific and Engineering Practices did we use?

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
Which *cross-cutting concepts* did we address?

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change
Why does coherence matter?

Concepts and Practices Storyline

Focus Question 1: Where does the water you need come from?

Lesson 1: H2O
Accessing freshwater is a problem
Students define the problem of freshwater not being available where it is needed. Students design and test a system for moving water a short distance.

Focus Question 2: How have humans impacted the water we need?

Lesson 5: Water Pump
Identifying failure points informs how to improve a design
Students consider the structure and function of various tools in order to design a solution for pumping groundwater to the surface. Students communicate possible solutions to failure points encountered during system testing.

Focus Question 3: How have humans tried to solve the problem of getting freshwater to where it’s needed?

Lesson 6: The Global Water Connection
Humans Impact Earth’s four spheres
Students evaluate informational text in order to communicate information with peers about a particular sphere of the Earth. Students explain how one component of the Earth system is affected by or affects humans.

Lesson 7: Water Web
Earth’s four spheres interact
Students develop a model by connecting the components of Earth’s four spheres. Students use that model to make predictions about the effects of possible future events.

Lesson 8: Clean the Water—Design It
Human activities impact groundwater
Students develop a model to show how human activities interact with components of the Earth system to cause groundwater pollution. Students design a solution to a water pollution problem.

Lesson 9: Clean the Water—Test It
Design solutions should be compared based on how well they meet the criteria
After testing water treatment systems, students analyze and interpret quantitative data in order to compare different design solutions. Students use evidence to construct an explanation about which solution best meets different criteria.

Focus Question 4: How can we provide freshwater to agriculture, industry, the environment, and housing in your town?

Lesson 10: Aquation
Human activities impact water availability and distribution
Groups of students use a model simulation to define the problem and design a solution to the water scarcity and water equity problem using existing technologies.

Lesson 11: Unintended Consequences—Read All About It!
Human activities can have unintended consequences
Students obtain and evaluate information from two different perspectives on the cause and effects of the Aral Sea environmental crisis.

Lesson 12: Unintended Consequences—Write All About It!
Human activities can have unintended consequences
Groups of students evaluate and communicate information on the cause and effects of the Aral Sea environmental crisis by writing a newspaper article.

Lesson 13: Water Ready?
Earth’s four spheres interact
Students prepare for a design challenge by developing and using models to show the interactions of groundwater with other components of the Earth system. Students communicate a strategy to preserve water to a specific stakeholder.

Lesson 14: Get It, Treat It, Share It Part 1
Communication with peers is an important part of the design process
Groups of students evaluate information about a specific town in order to design a solution for accessing and treating water that meets specified criteria and constraints. Students analyze and interpret data to figure out effects of design choices in previous testing.

Lesson 15: Get It, Treat It, Share It Part 2
Identifying failure point informs how to improve a design
Groups of students carry out a live system test and analyze and interpret their findings. Groups communicate failure points that affected the overall system and a possible solution to that failure point.

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What are the cognitive benefits of integrating hands-on learning with digital learning?

The power of physical 'stuff' in our digital world | Carol O'Donnell | TEDxFoggyBottom

https://www.youtube.com/watch?v=B7NPtCOPAZ4
Examine Data that Proves this Works
A 5-year randomized control trial study that “Met Work Works Clearinghouse Standards Without Reservations” showed teachers across 3 states (TX, NC, NM) in 16 districts teaching 9,000 students felt more prepared to teach inquiry. The training is fantastic! http://bit.ly/training-is-fantastic
Classroom observations showed students demonstrated more collaboration and worked in teams to solve problems compared to students in traditional classrooms.

Students were able to apply what they had learned to solving real science problems*

* Statistically significant difference (less than 5% chance the difference was due to chance)

# Meaningful difference (greater than .25 effect size, calculated by subtracting gains of comparison from gains of treatment and dividing by pooled SD)

*Individual-level inferences with no clustering corrections, which meet WWC standards with reservations
Underserved students scored higher on the science performance task compared to underserved students not in schools using traditional teaching methods*

- ELL = English language learners
- IEP = students with individualized education programs
- FRL = students participating in free or reduced-price lunch program, a proxy for SES (FRL)

*Individual-level inferences with no clustering corrections, which meet WWC standards with reservations
A hands-on plus digital approach to teaching science lead to higher reading and math scores*.

*Individual-level inferences with no clustering corrections, which meet WWC standards with reservations.
Impacting Student Learning: A Texas Example

https://www.youtube.com/watch?v=HE1RH6FvumM
Thank you!

Dr. Carol O’Donnell

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