Engineering a Habitat's Humidity

Subject Area(s) Physical Science, Nature of Science

Associated Unit **None**

Associated Lesson **None**

Activity Title Engineering a Habitat's Humidity

Image 1

Image file: Condensation on a window

ADA Description: Image of water droplets forming on a window. Someone has touched the water droplets and there are finger streaks going through the water.

Source/Rights: © https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwj89J6I0fbbAhUmja0KHZ53AhQQjRx6BAgBEAU&url=https%3A%2F%2Fwww.flickr.com%2Fphotos%2Froland%2F8532795969&psig=AOvVaw0A6uIxLZRSy6RlyxYib6LD&ust=1530284712162949

Caption: Condensation forms on a window, creating water vapor, which means there is humidity in the air.

Grade Level 3 (3-5)

Time Required 45 minutes/day for 11 days

Group Size 3-4

Expendable Cost per Group US $25.00

Summary

Students will be designing an optimal temporary habitat for a future classroom pet, a hingeback tortoise. Based on background research conducted, students will identify what humidity percentage this type of tortoise needs, as well as what its habitat is like. The class will be divided into groups and will investigate habitat features such as, how many holes the habitat needs, what type of bedding, and how much water is ideal for the hingeback tortoise's humidity level of 70-80%. Each group will communicate and present this information to the rest of the class after they research, brainstorm, collect and analyze data, and design their final plan.

Engineering Connection

Engineers solve problems and discover practical solutions that impact people's everyday lives. Designing an optimal temporary habitat for a future classroom pet is relevant to students' lives because they will see and interact with the animal and habitat every day in their classroom. Students are thinking as engineers do as they

investigate and examine each variable through research and design; also, while retesting different solutions.

Engineering Category = 3
Choose the category that best describes this activity's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords condensation, evaporation, humidity, water vapor, habitat

Educational Standards

State STEM Standards

- **SC.3.N.1.1** Raise questions about the natural world, investigate them individually and in teams through free exploration and systematic investigations, and generate appropriate explanations based on those explorations.
- **SC.3.N.1.3** Keep records as appropriate, such as pictorial, written, or simple charts and graphs, of investigations conducted.
- **SC.3.N.1.4** Recognize the importance of communication among scientists.
- **SC.3.N.1.5** Recognize that scientists question, discuss, and check each other's' evidence and explanations.
- **SC.3.N.1.6** Infer based on observation.
- **SC.3.P.8.2** Measure and compare the mass and volume of solids and liquids.
- **SC.3.P.8.3** Compare materials and objects according to properties such as size, shape, color, texture, and hardness.
- **SC.3.P.9.1** Describe the changes water undergoes when it changes state through heating and cooling by using familiar scientific terms, such as melting, freezing, boiling, evaporation, and condensation.

- **MAFS.3.MD.1.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units.

- **LAFS.3.W.2.4** With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose.
- **LAFS.3.W.3.7** Conduct short research projects that build knowledge about a topic.
- **LAFS.3.SL.1.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.

- **LAFS.3.SL.2.4** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

ITEEA Standards

- **Standard 8.** Students will develop an understanding of the attributes of design.
  In order to realize the attributes of design, students should learn that:
  C. The design process is a purposeful method of planning practical solutions to problems.
  D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
- **Standard 9.** Students will develop an understanding of engineering design.
  In order to comprehend engineering design, students should learn that:
  C. The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  D. When designing an object, it is important to be creative and consider all ideas.
- **Standard 10.** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
  C. Troubleshooting is a way of finding out why something does not work so that it can be fixed.

NGSS Standards

- **3-LS4-3** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5 ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5 ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Pre-Requisite Knowledge

Students should know the basics of their lab notebooks: how to start an entry and what to write based on their observations and data. Students should also have a basic understanding of the three states of matter: solid, liquid, and gas.

Learning Objectives

After this activity, students will be able to:

- Understand that when condensation forms, humidity is present.
- Identify humidity as the amount of moisture, or water vapor, in the air.

- Understand evaporation is when liquid turns into a gas and condensation is when a gas turns into a liquid.
- Measure mass and volume of an object using a scale and a graduated cylinder.
- Identify materials according to properties such as size, shape, color, texture, and hardness.
- Develop an understanding of the engineering design process.

Materials List

Each group needs:

- 6-quart plastic bins/lids- might need more or less depending on how many groups and sizes (2 per group)
- Small-sized rectangular plastic bins/lids (2 per group)
- Soil
- Mulch
- Sand (collected outside or bought)
- Container for sand
- Plastic cup to scoop each bedding
- Water
- Hygrometer
- Spray Bottle
- Graduated Cylinder
- Chart Paper/Markers

To share with the entire class:

- Electronic Digital Scale
- Small bin to put on scale when measuring
- Gloves
- Computers/laptops
- Books or printed information on hingeback tortoises (see references section)
- Knife or hot-glue gun (for teacher to make holes in plastic)
- Book: *The Problem with Moisture- Humidity for Kids*

Each student needs:

- Lab Notebook
- Pen
- Chart A and B
- Design Plan Sheet
- Final Design Rubric
- Post-Activity Exit ticket

Activity Overview:

Day 1: KWL Chart/Read Book
Day 2: Video, Introduce Problem
Day 3: Research
Day 4: Practice Design 1
Day 5: Practice Design 2
Day 6: Data Collection
Day 7: Tortoise Design 1
Day 8: Tortoise Design 2
Day 9: Data Collection
Day 10: Poster Draft/Final
Day 11: Presentations

Introduction / Motivation Day 1
Display a KWL (Know, Want to Know, Learned) chart. For the title, write *condensation* and *evaporation* and read it to the students. Ask the students what they already know and put their comments in the K column. If students are having difficulty, remind them about the water cycle. Then ask what they want to know and put it in the W column. Leave the chart up for reference.

Ask students: *Have you ever felt moisture outside even though it wasn't raining? Where do you think that wet feeling comes from? Do you think that happens everywhere in the world?*

1. Gather students in a central area to read *The Problem with Moisture- Humidity for Kids*. Before reading to the students, ask prediction questions such as:
    - *What do you think these pictures mean?*
    - *What do you think this book will be about?*
    - *Do you think it is a fiction or nonfiction book? How do you know?*
    - *What does the title tell me about this text?*
2. While reading, answer questions as needed. Ask the students questions such as:
    - *Who has ever seen a window or glass with condensation on it?*
    - *Who has ever heard a weather reporter talk about humidity?*
    - *Is a 20% or a 99% humidity level have more water vapor in the air?*
    - *Do you think there is more humidity in Florida or Africa? Why?*

3. After reading, ask if students still have questions. If they do, add to the W column. Discuss the connection between humidity, condensation, and evaporation.
4. Optional: have students write on a sticky note the most interesting fact they learned from the book.

Vocabulary / Definitions

Word	Definition
Condensation	A change in matter in which water changes from a gas to a liquid.
Evaporation	A change in matter in which water changes from a liquid to a gas.
Relative Humidity	The amount of water vapor, or moisture, found in the air, compared with how much water could be in the air; measured in percent (%).
Water Vapor	The gaseous state of water.
Habitat	The natural home or environment of an animal.

Lesson Background & Concepts for Teachers
The purpose of this lesson is to investigate evaporation and condensation in the form of humidity found within the real world. Students learn about states of matter and the changes water undergoes through heating and cooling, specifically condensation and evaporation. Students will have to understand that the presence of water and heat (formed within the box with a lid and/or air holes) will form condensation in the tortoise's habitat, which means humidity is present.
It is important to note the connection between humidity, condensation, and evaporation in the students' habitats. When they close the lids of their enclosures (with

air holes in them), the water is trapped, and moisture is created. Depending on the amount of the students' holes, evaporation will occur at a certain rate. If the bins have less holes, the liquid will not evaporate as quickly, and the humidity will be held in, but if the bins have more holes, the liquid will evaporate quicker and less humidity is present. Hingeback tortoises require a 70-80% humidity in their enclosures for optimal living and health. Thick soil will hold in the humidity the most, rather than the mulch or sand. However, based on how much water is sprayed into the habitat and how many holes are present, mulch will work as well (see articles in reference section).

Procedure

Before Day 2:

- Gather materials: lab notebooks, pens
- If you have access to BrainPOP, Jr., play the *Changing States of Matter* video. If you do not, play this video.

With the Students:

- Play the video and discuss with students the changing states of matter: freezing, melting, condensation, and evaporation afterwards. Write these four words on the board and have the students copy in their lab notebooks. With the help of the students, write the definitions of each word and any other things learned through the video. Encourage students to draw pictures representing that word. For example, by *condensation*, they can draw a glass of water with droplets forming on the outside. Have students draw a star by *condensation* and *evaporation*.
- Introduce the scenario: they will be getting a classroom pet, a hingeback tortoise; show pictures on the Internet (you can tell the students that it is for fun or that the class will really be getting a pet). Say: *The problem is that you have to design a habitat yourselves for a baby hingeback tortoise to start in before the materials for his permanent habitat I've ordered come in. However, like all animals, a hingeback tortoise has a very specific way it likes to live, and it likes a very specific humidity level in order to grow. We need that humidity level to stay constant for at least 24 hours when we can come back and readjust as needed. You will be engineers because you are designing something to help us solve a problem. You will first be conducing research and collecting information from the Internet, articles, and books like real engineers do when presented with a problem they want to solve in order to make smart and informed decisions about their designs.*

Before Day 3:

- Gather materials: lab notebooks, pens, computers/laptops, books about hingeback tortoises (if those specific books cannot be found, print out articles found in the reference section)

With the Students:

1. Research Day! Remind students that engineers conduct research on a topic before the actual design to see if there is information already out there to help. Brainstorm with the students what things they should be researching and write ideas on the board; have students copy in their lab notebooks.

- What humidity percentage does the hingeback tortoise prefer?

- What type of materials or objects should be in the habitat to hold in humidity?
- How much water should I spray into the habitat?

2. Each student receives a laptop to conduct research on the hingeback tortoise (if there aren't enough laptops for every student, have them do it in rotations with other students looking through books or care articles). Students will write any relevant information in their lab notebooks in complete sentences. Remind students to use neat handwriting since engineers need to be able to read their notes to complete their designs correctly and also because other engineers might want to replicate their designs.
3. Put a hygrometer in a central location in the classroom to measure the room's humidity level to tell the students. This should inform their choices when deciding materials/amounts.

Before Day 4:

- Gather Materials: small plastic bins with lids, soil, mulch, sand, cups, gloves (when touching bedding material), water, graduated cylinders, spray bottles, scale, bin (to tare scale), hygrometers, knife or hot-glue gun, design plan sheet (attachment 1)
- Divide the class into 4-5 heterogeneous groups

With the Students:

1. Students are going to practice designing a habitat on a smaller scale using their research they collected the previous day. Tell students they aren't going straight into designing their tortoise habitat because good engineers try all of their ideas first before their final design.
2. Show students the different materials they are allowed to use. Tell students that they have three things they need to decide to achieve the humidity level needed (70-80% for 24 hours): how many air holes to put into the bins, what type of bedding to use (planting soil, mulch, or soil) and how much water to spray into the habitat (Image 2)*. Tell them that you will have a knife or hot-glue gun** ready to make holes into the bins with; have the students draw on the bins where they want the holes to go and you will make them when ready.
*You might need to limit the amount of starting water in the bottles so that students don't use too much. Tell the students that the bedding should not be soaked because the tortoise needs to be able to walk around comfortably.
**The hot-glue gun is easier to make holes with than the knife. To do so, press the gun where the hole is desired and leave for a few seconds.
3. Introduce yourself as the PI, or Principal Investigator. The PI is in charge of all of the groups and their work. Groups must get permission from the PI to begin working after approving their design sheet, just like real engineers do. Pass out a design plan sheet (attachment to each student (they will use this for all 4 designs. Have students glue in lab notebooks or keep in a folder). Groups will discuss with each other first what they want, write it on their design plan sheet, and then come up to gather materials one at a time distributed by you. Check students' design plan sheet and give feedback if necessary. Read the hygrometer in the room and write it on the board and lab notebooks. Tell students they need to keep the classroom's humidity level in mind when designing the habitat.
4. In order to know how much bedding and water is used, students will need to measure***. For the bedding, show students how to tare the digital scale with a plastic

box first, then put how much bedding they want to use in the box, and record the mass in grams. For the water, they will need to put water into a graduated cylinder, note the level in milliliters, and pour it into a spray bottle. After they are done spraying their habitat, they will pour the remaining water back in and record the level, then subtract the two numbers to get the amount used. Note that the class is sharing the scale. Tell students that this is done purposely because engineers sometimes have to share their lab equipment.
***You may limit the amount of dirt and water.
5. When they are completely done, have students put one hygrometer into the habitat to record the humidity level. Ideally, place habitats near a window or warm area to increase humidity.
6. Have the students record the bedding's properties: texture (moist or dry), color, hardness.
7. To examine condensation more closely, put in soil and spray water into your own small plastic box without any holes. Let it stay overnight and show it to students the next day; keep it closed for more condensation.

Before Day 5:

- Gather Materials: same materials as previous day, round 1 practice habitats

With the Students:
1. Record the date, time, and humidity levels present in each group's small habitat in lab notebooks. Note the bedding again in lab notebooks.
2. Ask students to take note if they see condensation in their habitat.
3. Ask each group to come together and discuss why they think their humidity level was too low, too high, or just right. Discuss with the class what they think they need to change to achieve that perfect humidity level and record it in their lab notebooks. (examples: change the soil to sand, add less holes, spray more water, spray less water, etc.). You want the students to come up with these as much as possible; tell students that when faced with a task, engineers try multiple solutions.
4. Students will repeat this process one more time with their changes. Students record ideas on design plan sheet. Redistribute materials.

Before Day 6:

- Gather Materials: round 1 and 2 practice habitats, lab notebooks, pens, chart A (attachment 2)

With the Students:
1. Examine and record humidity levels. Repeat the same process as the previous day: why did your small habitat achieve that humidity level? What did you change? Did it make the humidity level change?
2. Distribute charts and have students glue in their lab notebooks; show one on the board. Assign each group a number. Have each group fill in the information for their own row only. Go around and fill in each group's row on the board; have students copy in their charts.
3. As a class, discuss what worked and what didn't.

Before Day 7:

- Gather Materials: 6-quart plastic storage bins with lids, soil, mulch, sand, cups, gloves, water, graduated cylinders, spray bottles, scale, bin, hygrometers, knife or hot-glue gun, design plan sheet

With the Students:

1. Tortoise Habitat Design Day! Groups will first brainstorm a design for the hingeback tortoise's habitat. Tell them that they will be using their research from the Internet, books, and previous experiment to design the most optimal habitat for the tortoise. Remind the students that the tortoise prefers 70-80% humidity, so it is important to keep that in mind when using certain materials.
2. Distribute materials the same way as the small practice habitats, just with the 6-quart storage bins instead. Students will design on the design plan sheet first. Remind students that this design is bigger, so their variables might have to change as well. Have students create habitats, place hygrometers inside, and place in the same area as the practice designs.

Before Day 8:

- Gather Materials: same materials as previous day, round 3 tortoise habitats

With the Students:

1. Record date, time, and humidity levels present on hygrometers in lab notebooks.
2. Groups will have one more chance to improve their design if needed. Have groups discuss what they should change and record on their design plan sheet. Redistribute materials. Have students create habitats and place in the same area as the previous habitat.

Before Day 9:

- Gather Materials: round 3 and 4 habitats, lab notebooks, pens, chart B (attachment 2)

With the Students:

1. Come back and record humidity levels present on hygrometers.
2. Distribute chart B to each student. Have groups write in the same row as the last chart. Ask each group their information and fill in on the board; have students copy.
3. As a class, come together and discuss what worked and what didn't. Encourage students to think about *why* the humidity levels were like that. Discuss whether they could see the condensation in the habitat. Discuss how they made the humidity level more stable the second time and how they acted like engineers.

Before Day 10/11:

- Gather Materials: chart paper for each group, markers, lab notebooks, pens

With the Students:

1. Students will receive one piece of chart paper and markers to present their design to the rest of the class. Say: *engineers share their final designs with other engineers so that they can learn from their data. Also, other engineers might want to repeat the process and see if they can get the same results.*
2. Things students want to include on their paper (write on board):
   - Problem: can we design a hingeback tortoise habitat that obtains 70-80% humidity for at least 24 hours?
   - Drawing of their final design

- Practice habitats and humidity data
- Final habitat humidity data
- What they changed
- If they observed condensation in any of their designs
- Science behind the challenge
- Any other observations

3. Presentations are on day 11. Give students time to practice. They can also write what they want to say on index cards. Encourage every student in the group to speak at least once.
4. Grade students according to the engineering rubric (attachment 3). Give students the post-activity assessment (attachment 4).

Image 2

Image file: Students creating a habitat

ADA Description: One student is holding the practice habitat full of soil up while another student is spraying water into the habitat. Another student is observing. A graduated cylinder is near that was used to measure the water put in the spray bottle. Students are wearing gloves for protection.

Source/Rights: ©2018 Kayla Sutcliffe

Caption: Working together to create an ideal habitat!

Attachments

1. Design Plan Sheet
2. Charts for Lab Notebooks
3. Engineering Rubric
4. Post-Activity Assessment

Safety Issues

- Do not let the students cut their own holes. Have them draw circles on their bins with a marker and take it to the teacher.
- Do not make holes in lids (they will be too brittle); make holes on sides of plastic bins. If you'd like, practice making holes with a knife or hot-glue gun first before the students' designs.

Troubleshooting Tips

- If there is not enough condensation to produce humidity in the students' habitats, make sure they understand they need more water vapor to somehow stay inside less holes, more water, different bedding). If there is too much condensation, they will need to figure out a way to decrease it (more holes, take lid off half way, different bedding, less water).
- Be aware of the humidity level in the classroom; it might affect the habitats. Measure it beforehand and tell the students the level.

- Place the hygrometers in the same area of each group's habitat every time for consistent results.
- When students are to record data in their lab notebooks, some might need more help with others. Try putting sentence stems on the board. Encourage students to help each other and walk around to help.
- If the students put the lid completely on, it will most likely produce >90% humidity. When they test this, they should realize they need to take the lid off.

Investigating Questions

- What is the connection between humidity, evaporation, and condensation?
- What would you have to change in order for the humidity to increase/decrease in your habitat?
- What is another way you can change the habitat's humidity instead of…?

Assessment

Pre-Activity Assessment

Pre-Activity Assessment conducted as a class in introduction with a KWL chart.

Activity Embedded Assessment

The Day 6 (practice designs) and Day 9 (tortoise designs) chart will serve as an activity embedded assessment (see attachment).

Post-Activity Assessment

See Attachment 3 for design rubric
See Attachment 4 for exit ticket

Activity Extensions

- Students can research different tortoises or reptiles that require a different amount of humidity, then brainstorm and plan in their lab notebooks the best way to design its habitat.
- Have students research what would happen if the weather became cold and the humidity was harder to maintain.
- Take photographs of groups' habitats final design and create a class book.
- Using Google Slides, have students create their presentation in a digital format.

Activity Scaling

- For lower grades:
    - Instead of focusing on the humidity percentage, K-2 students can observe the condensation and evaporation each day.
- For higher grades:
    - Students can predict whether they think water or salt water will create more humidity and test it using the other variables.
    - Students can research a different tortoise or reptile in smaller groups or pairs and research what humidity level they need and how to create their habitat accordingly.

Additional Multimedia Support

References

Reptiles Magazine. "Home's Hingeback Tortoise"
http://www.reptilesmagazine.com/Homes-Hingeback-Tortoise/

Reptile Talk. "Bell's Hingeback Tortoise"
https://www.reptiletalk.net/bells-hingeback-tortoise/

Contributors

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Classroom Testing Information

This unit was tested in September 2018 at Glen Springs Elementary School in Gainesville, FL in a 3rd grade classroom with 14 students.

Charts for Lab Notebooks

*****Change number of groups based on own group numbers.

Chart A

Practice Designs

	First Humidity Level (%)	*Second Humidity Level (%)*	*What did you change?*
Group 1			
Group 2			
Group 3			
Group 4			
Group 5			

Chart B

Hingeback Tortoise Habitat Design

	First Humidity Level (%)	*Second Humidity Level (%)*	*What did you change?*
Group 1			
Group 2			
Group 3			
Group 4			
Group 5			

Design Plan

Name _____

Design Plan #	Material(s)	What will your procedure be?	Sketch	PI Feedback
Practice Round 1				
Practice Round 2				
Tortoise Habitat				

3				
Tortoise Habitat 4				

Engineering a Habitat's Humidity Post-Activity Assessment

Name: _____

What is humidity?

_____

_____

_____ is when liquid turns into a gas.

_____ is when gas turns to a liquid.

How have you behaved like an engineer during this design process?

_____

_____

_____

_____

_____

Engineering a Habitat's Humidity Rubric

Criteria	4. Advanced Engineer	3. Proficient Engineer	2. Developing Engineer	1. Junior Engineer	Total
Research	Student shows evidence of extensive research about hingeback tortoises and their habitats in their lab notebooks.	Student researches about hingeback tortoises and their habitats in their lab notebooks.	Student has minimal research about hingeback tortoises and their habitats in their lab notebooks.	Student has little to no research about hingeback tortoises and their habitats in their lab notebooks.	
Planning	Student has a clear and concise plan in their lab notebook that shows what they will be using in designing their habitat.	Student has a plan in their lab notebook that shows what they will be using in designing their habitat.	Student has a plan in their lab notebook that might be hard to follow that shows what they will be using in designing their habitat.	Student has no plan in their lab notebook that shows what they will be using in designing their habitat.	
Design/ Redesign	Student designs an optimal habitat and redesigns as needed.	Student designs an appropriate habitat and redesigns as needed.	Student designs an appropriate habitat but does not redesign as needed.	Student does not design a habitat or attempt to redesign as needed.	
Presentation	Student speaks and presents their information clearly.	Student speaks and presents their information.	Student speaks quietly and only presents some of their information.	Student does not contribute to the presentation.	
Participation	Student was an active member of the group and contributed ideas as a leader.	Student was an active member of the group.	Student contributed to the group but was not actively involved.	Student did not contribute to the group.	

Total =

Teacher Comments:

_____

_____

_____