Q405 Saturday Science Teaching – Fall 2017

Lesson Plan Week #1

MAIN TITLE: Nature Inspired

SUB-TITLE (Biomimicry in Nature)

GRADE LEVELS: Grade 6-8

A) LEARNING OBJECTIVES and CRITERIA FOR DETERMINING IF OBJECTIVES ARE MET (minimum of 2/ lesson)

1. Students will be able to identify different structural features in nature
2. Students will understand the facets of biomimicry
3. Students will be able to create connections between inventions and the inspirations in nature
4. Students will be able to effectively apply themes in nature to biomimicry

Focus question: What is biomimicry and how does it affect our life?

B) STANDARDS (see http://www.doe.in.gov/standards/science)

Science and Engineering Process Standards:

SEPS.1 Posing questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools

Content Standards:

6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem.

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

8.ESS.3 Research how human consumption of finite natural resources (i.e. coal, oil, natural gas, and clean water) and human activities have had an impact on the environment (i.e. causes of air, water, soil, light, and noise pollution).

C) MATERIALS (asterisk (*) = any materials that may be a safety concern)

- Newspaper (20)
- Modge podge (2 gallons - for all 5 weeks)
- Water

- Bins (6)
- Balloons*(latex allergy) (25)
- If possible, several pairs of binoculars
- Blank computer paper
- Markers

D) TEACHER CONTENT KNOWLEDGE

- We need to know the definition of biomimicry
- We need to know about the several different types of birds nest we will be introducing to them
- We need to be familiar with biomimicry inventions

E) REFERENCES (list <u>ALL</u> references that you borrowed ideas from to develop this lesson – including any handouts you may distribute)

https://www.thespruce.com/types-of-bird-nests-386664

https://www.bloomberg.com/news/photo-essays/2015-02-23/14-smart-inventions-inspired-by-nature-biomimicry

http://infographicjournal.com/what-is-biomimicry-innovation-inspired-by-nature/

Link to the PowerPoint we created to use during this lesson:
https://docs.google.com/presentation/d/1YbGubIKel3NdrWbyCGjGskw04ThcPkui3wgdt8Aq1Ao/edit?usp=sharing

F) TENTATIVE TIMELINE

25: Icebreaker, meet everyone in the class

- Ice breaker description: Students will be given a blank sheet of paper and instructed to draw a blank face and t-shirt. They will then be given 5-7 minutes to draw a "blind" self portrait. They must close their eyes and draw a self portrait. On the t-shirt, they should draw one thing they like about STEM (draw a bridge if they like engineering, something for math, something about science, etc.)
- Afterwards, students will share out their self portrait with the class

10: Write biomimicry on board and have them brainstorm with their table what this could mean

- First five minutes: tables should discuss as this table what they think biomimicry means

- Last five minutes: Bring students together. Ask what they think the word means and why. If needed, break down the word with students, point out the bio prefix and the word mimic
- Write down their final definition on the board. Revisit this definition later during the biomimicry debrief and explanation to compare what they said vs. what they know by the end of the lesson, and what definition we give them.

10: Look at inventions (ones they aren't going to find outside) and see how they could be inspired by nature

- Slides 4-8 on the powerpoint
- Tell students that on one side there is an invention, and on the other side there is a picture of it's nature inspiration component. If the invention is shown, ask them what in nature might have inspired it. If something natural is shown, ask students what invention it may have inspired.
- After they guess, remove the blue box to reveal both images. Ask students where they see nature represented in the invention.

50: Have them go outside and search for objects in nature that could connect to inventions or inspired inventions. Break up in teams for each team to go to a different area and rotate. (Different areas includes prairie, stream and forest) Draw at least one thing that could inspire an invention and why, or draw an invention.

- Questions for students to consider when outside (Show them this before going outside):
    - What structures do you notice?
    - Can you find any animals habitats?
        - What are important aspects of the habitat?
        - Can we apply that to humans?
    - Can you relate something you see to an invention you know of?
        - Why might we have mimicked this?
        - How do we benefit?
    - Look at what you see. Could you invent something with what you find?
- Split students into groups of 8. One group will go to the stream, one group will go to the wooded area, one group with go the prairie area.
    - Each group will be with at least 1 Saturday Science volunteer
    - Groups should stay at their spot for 10 minutes, then their volunteer will take them to their new spot (10 minutes at each place)
- Suggestions you can make for students getting stuck:
    - Look at how wide a leaf is - this is good so that it can absorb a lot of sunlight. Compare this to solar panels.
    - Look at a bird and how its body is shaped - this is similar to an airplane.

    - Tree bark is very tough and covers the exterior of a tree to protect it - when else we might use tough protection?

10: Debrief

- Have students share their drawings and inventions at their table
- Present question to entire class: What were some of the things you looked at when coming up with your invention? What criteria did you have when choosing what components of nature to use?

10: Background information on biomimicry

- Ask students "Based on your time outside and having looked at the examples we saw of biomimicry we saw earlier, has your definition changed?"
- Show students the definition of biomimicry and biomimicry infographic on slide 10

10: Talk about different types of birds nests (how they can be effective)

- Preface this activity with the idea that we will be doing a "biomimicry challenge."
- This week the focus will be on shelter, specifically birds nests. There are many types of birds nests, each with different pros and cons. Show powerpoint slide 11, which reviews the basic reasons for bird's nests.
- Review powerpoint slides 12-19 which each have a different type of birds nest, and ask students to point out what they think the benefits of each nest are (do this before talking about the nests - see what students think before telling them)
- Ask students which bird's nest humans might want to take features from, and why? Which nest has features that would be good for humans to adopt when building?

35: Make shelter with materials. How does this relate to biomimicry?

- Criteria for building:
    - They are not building a birds nest, they are building a shelter that takes inspiration from the bird's nests
    - They should pick at least one component of bird's nests to focus on (although they can have multiple!) This can include but is not limited to:
        - Overall aesthetic appeal
        - Sturdiness/stability
        - Where it can be used as a shelter (Burrow/a hole somewhere/hanging from something/etc.)
        - Temperature/insulation
        - Comfort
    - While some glue will be provided, this should not be a main component. Students should figure out how to weave/tie/layer/etc. the materials together in order to create something.
- Students do not to finish this activity this week. During week 2, they will be given time to finish and there will be a debrief session.

G) DESCRIPTION OF YOUR LESSON

ENGAGE - Have all students engaged in the icebreaker. This will get students excited about the class and start a conversation about STEM - Write biomimicry on the board and have students engaged in trying to figure out what the word means.
EXPLORE - Have students explore different examples of biomimicry by showing them pictures of either and adventure or nature. They will guess what the opposite example is (For inventions, guess what in nature inspired it. For nature, guess what invention it inspired.) - Have students go outside and find biomimicry ideas for themself through exploration with surrounding nature. They will go explore outside and try to find examples of biomimicry or inspiration from nature for a new invention. Students should sketch their ideas - Take class time to go outside and get students inspired and thinking creatively by drawing biomimicry inspiration from nature.
EXPLAIN - Have students explain how a certain aspect of nature they have drawn could be used to create inventions. - Give a short explanation about the official biomimicry definition and examples of biomimicry. - Give a presentation about different types of birds nests and have students discuss and explain what the pros and cons of each bird nest design is - Have students create explanations for how their shelter represents their specific type of nest. (This will most likely be covered in the following week since we will finish building the shelters and have a debrief at the start of class 2)
ELABORATION - Shelter activity - students should take the knowledge they learned about birds nests and biomimicry and apply it to building their shelter. They should consider what are important aspects of a shelter, and why we may want to replicate them (comfort, warmth, where it is located,

safety, etc.). They will provide and explanation and elaborate on this more in the week 2 discussion about their shelters.

H) EMBEDDED FORMATIVE ASSESSMENT (the 5th "E")

- When we are presenting a Powerpoint on biomimicry we will ask students what they think this was based off of in nature before we tell them so that we are sure they understand biomimicry.
- Look over drawings in groups outside to be sure students are understanding the term biomimicry.
- Assess students' ability to create accurate bird nests based on the type they are creating by checking in throughout the creation time.

I) GEARING UP/GEARING DOWN

1. Gearing up:

- Have them draw more than one picture inspired by nature that could be used for biomimicry while outside.
- Have them create their own invention through drawing based upon something that they see in nature and write about its meaning while outside.
- Have them identify how their specific type of nest would make sense for the certain bird types that would live there.

2. Gearing down:

- Have them draw an existing invention using that biomimicry that we talked about in class rather than creating their own.

(Insert any handouts here)
https://docs.google.com/presentation/d/1YbGubIKel3NdrWbyCGjGskw04ThcPkui3wgdt8Aq1Ao/edit?usp=sharing

Q405 Saturday Science Teaching – Fall 2017
Lesson Plan Week #2
Patterns in Nature
GRADE LEVELS: 6-8

A) LEARNING OBJECTIVES and CRITERIA FOR DETERMINING IF OBJECTIVES ARE MET (minimum of 2/ lesson)

1. Students will be able to identify multiple patterns in nature
2. Students will be able to identify how this pattern can benefit humans
3. Students will be able to brainstorm ideas for how they can improve or invent something that can solve a problem

B) STANDARDS (see http://www.doe.in.gov/standards/science)

- **Science and Engineering Process Standards:**

SEPS.1 Posing questions (for science) and defining problems (for engineering)

SEPS.2 Developing and using models and tools

- **Content Standards:**

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

C) MATERIALS (**asterisk (*)** = any materials that may be a **safety concern**)

- Last week's bird nest supplies
- 6 iPads
- Green screen
- 6 white poster boards
- 6 boxes of marker
- 24 pencils
- 30 pieces of white paper
- 25 pieces of chart paper
- Handout with brainstorm sheet
- DoInk app

D) TEACHER CONTENT KNOWLEDGE

- We need to know about the Fibonacci sequence
    1-Who Fibonacci was (italian mathematician from republic of pisa)
    2-You can find one number by adding up the two prior numbers
    3-As an expression it reads $x_n = x_{n-1} + x_{n-2}$.
- We need to know how the Fibonacci sequence presents itself in nature
    1 - Shells
    2 - Pinecones
    3- Roses
- We need to know about patterns in nature (water cycle, camouflage, symmetry, waves, moon phases, seasons, weather patterns, photosynthesis)

E) REFERENCES (list **ALL** references that you borrowed ideas from to develop this lesson – including any handouts you may distribute)

- https://www.youtube.com/watch?v=ahXIMUkSXX0&feature=youtu.b

Snack Time Videos:

1. https://www.youtube.com/watch?v=T_yxZFjqQUg
2. https://www.youtube.com/watch?v=JSEQvyjACyA&index=69&list=PLsNB4peY6C6JGmzQ5bAirihLWMeyQUX-0
3. https://www.youtube.com/watch?v=c5v377erIkc

F) TENTATIVE TIMELINE

- 9:30-9:40 am (10 min) Classroom expectations discussion
    - Remind students that they should be respectful of all opinions shared in the class (safe place)
    - Stories should be saved for a different time - focus on sharing comments directly related to the questions we are asking
    - Do not leave the room until someone has signed you out
- 9:40-9:55 am (15 min) Bird nests
    - Give students 10-15 minutes to finish constructing their shelters, clean up, and share their creations
- 9:55-10:20 (25 min) - Discussion and exploration about Fibonacci sequence
    - Explore thumbprints and look for patterns
    - Compare thumbprint swirl to roses, shells, pinecones, and leaves
    - Explain the fibonacci sequence and watch video
- 10:20-10:50 am (30 minutes) Discussion/exploration about patterns in nature

    - 10 minutes - Discussion about patterns in nature and why we want to understand them
    - 20 minutes - Time to go outside and look for patterns in nature
- 10:50-11:05 am (15 min) Snack/Bathroom break
    - Play these videos during snack
        - https://www.youtube.com/watch?v=T_yxZFjqQUg
        - https://www.youtube.com/watch?v=JSEQvyjACyA&index=69&list=PLsNB4peY6C6JGmzQ5bAirihLWMeyQUX-0
        - https://www.youtube.com/watch?v=c5v377erIkc
- 11:05-12:00 am (55 min) Creating "episode" for Science Channel video about patterns in nature
    - Students should choose a pattern in nature and plan a video that explains this pattern in nature and answers the questions above
    - Pull students out of the classroom to film their video with the green screen
        - After filming their video, students should edit the video on their iPad using DoInk
    - If students finish creating their videos with time left over, they can create a poster to go along with their "episodes"
    - We will watch the videos that they created in the following week
    - If there is still additional time where students are done, they can do a fibonacci drawing on the back of their PSA poster

G) DESCRIPTION OF YOUR LESSON

ENGAGE

- Collect student thumbprints as soon as they come into the room. If they ask what it is for, do not tell them. This is to start a discussion about patterns.
- Show the thumbprints up on the document camera. Ask students what they notice about the thumbprints. What do they look like? Do they notice a pattern?
- Explain to students that they are looking at examples of the fibonacci sequence. Provide some background information about what the fibonacci sequence is
    - Fibonacci was a an Italian mathematician
    - The fibonacci sequence follows a swirling pattern
- Pass out the roses, pinecones, leaves, and shells. Ask students to compare the leaves, roses, pinecones, and shells to the swirl of the thumbprints.

- Do they notice any similarities?
- Are there any differences?
- Does it look like any of the objects also follow the fibonacci spiral pattern?
- Ask each table to share out which of the objects they thought were also examples of the fibonacci sequence and why

- Tell students that the leaves, pinecones, and shells were examples of the fibonacci sequence. Show them how the spirals follow that same pattern.
- Finally, allow students to explore the actual mathematical equation that explains the fibonacci sequence
  - Write "0, 1, 1, 2, 3, 5, 8, _, _, _" on the board and tell students to try and guess the next three numbers of the pattern
  - After students have tried to figure out the pattern, have them share out. Give students the answer (next 3 numbers are 13, 21, 34)
- Finish with this video explanation of the fibonacci sequence (link)

EXPLORE

- Use the fibonacci example as a segway into a discussion about the importance of patterns in general. Use the following questions to facilitate discussion:
  - Why would we want to look for patterns in nature?
  - How do we benefit from natural patterns, or how can we use them?
  - Ask every group to brainstorm one pattern or cycle they know of in nature. Examples:
    - Water Cycle
    - Photosynthesis
    - Moon phases
    - Tree rings
    - Leaf structure
    - Seasons
    - Weather Patterns
    - Flowers
    - Pine Cones
    - Spider webs??
- Take students outside to look for patterns in nature

- Students should be relating patterns they see in nature to processes or inventions they see in society.
- They should be thinking about why those patterns are important and how understanding them is beneficial.
- They may also look for examples of the fibonacci sequence that were not addressed earlier.

EXPLAIN

- Ask students to explain the shelters they made and what materials they used.
    - This will take place at the start of the lesson but is part of "explain"
    - Ask the following questions to facilitate discussion:
        - Which bird's nest(s) did you draw inspiration from?
        - What are pros of your shelter? Are there any drawbacks to your design?
        - How did you construct your shelter? How did it emulate aspects of a nest?
- Students will now make a video explaining the pattern in nature they either came up with and observed outside, or a pattern they came up with on their own (similar to a PSA).
    - Frame this as students making an "episode" for an imaginary science channel
    - Students should choose one pattern to focus on (moon phases, pattern of veins on a leaf, bee hive honeycomb shape, etc.)
    - Things they should include in their video:
        - What pattern in nature are they focusing on?
        - Why is this pattern beneficial to know about?
        - Do you already see where humans have adopted using this pattern?
        - Where else might we use this pattern?
    - Students need to make a script for their video and find an image of the pattern that can be used as the background of their video
    - Pull students out of the classroom to film their video with the green screen
        - After filming their video, students should edit the video on their iPad using DoInk

ELABORATION

- Have students try to elaborate on the benefits of using aspects of bird's nests when building actual human shelters
    - This should take place at the start of the lesson (it is an elaboration on the bird's nests activity that was completed during week 1)
    - Ask the following questions to facilitate discussion:
        - What were some of the benefits of emulating aspects of a bird's nest? How did this help you with the construction of your shelter?
        - Can you think of other animal habitats that we could draw inspiration from?
        - Think about the way that we live and how our own homes are constructed. What from it reminds you of nature? Have we improved upon any natural structures?
- For the groups who finish their video early, they can elaborate on their pattern video by creating a PSA poster that displays a design they have created for human use that incorporates their specific pattern they chose to elaborate on.
    - Posters should include:
        - A drawing of their pattern
        - A brief explanation of their pattern
        - A "blueprint" of a new way humans can adopt the pattern and put it to use, or a drawing of how humans use the pattern now
- Groups who still have time leftover at the end of class should make fibonacci drawings on the back of their posters
    - Show students how to draw a fibonacci spiral
    - After they've done that, they should try to illustrate around the spiral and make it into a new image

H) EMBEDDED FORMATIVE ASSESSMENT (the 5th "E")

- Episode they create about specific pattern seen in nature
- Design something for human use that incorporates this specific pattern in nature

I) GEARING UP/GEARING DOWN

1. Gearing up:

- When creating their inventions we can not only have them incorporate a structure from nature as inspiration but also have them apply a pattern from

nature to their invention. If they finish an activity early we could have students create a drawing using the Fibonacci series.

2. Gearing down:

- To gear down this assignment for anyone who might have trouble understanding what the Fibonacci sequence is, how it appears in nature, or how patterns in nature influence inventions and processes in the real world, we can provide assistance, including examples from classroom discussion, or identify a pattern and have them explain how this pattern can be beneficial for human use/how it is seen already.
- If they are having too much trouble coming up with a NEW invention inspired by nature, take something already invented and IMPROVE it using inspiration from nature

Handouts:

Handout for brainstorm sheet:
https://docs.google.com/document/d/1sqancHl8ituUipQrZDUMWyCHw8LMCki964KfWDM6bes/edit?usp=sharing

Handout for video planning and blueprint:
https://drive.google.com/a/umail.iu.edu/file/d/0BwrpTLy9wn7ZalBKTlRJTENYVUE/view?usp=sharing

Gearing up Fibonacci worksheet
https://docs.google.com/a/umail.iu.edu/document/d/1fa2IYtiuaumi8tbzHNee-XjNhDBIW5ucCAYdZ0StTl8/edit?usp=sharing

Q405 Saturday Science Teaching – Fall 2017
Lesson Plan #3

Biomimicry and Vessels

Sonar

GRADE 6-8

A) LEARNING OBJECTIVES and CRITERIA FOR DETERMINING IF OBJECTIVES ARE MET (minimum of 2/ lesson)

1. The students will be able to connect boat structure to aspects in nature
2. The students will be able to take their knowledge about biomimicry and apply it to their own inventions
3. Students will be able to analyze engineering ideas to better a boat structure

B) STANDARDS (see http://www.doe.in.gov/standards/science)

- **Science and Engineering Process Standards:**

SEPS.2 Developing and using models and tools

SEPS.3 Constructing and performing investigations

SEPS.4 Analyzing and interpreting data

SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)

SEPS.7 Engaging in argument from evidence

SEPS.8 Obtaining, evaluating, and communicating information

- **Content Standards:**

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem.

6-8.E.3 Analyze data from investigations 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.

6-8.E.4 Develop a prototype to generate data for repeated investigations and modify a proposed object, tool, or process such that an optimal design can be achieved.

C) MATERIALS (**asterisk (*)** = any materials that may be a **safety concern**)

- Styrofoam (6 large sheets, ½ inch)
- Water bin (long plastic black thing)
- Saran wrap (1 large roll)
- Aluminum foil (1 large roll)
- Construction Paper (1 pack)
- Wooden skewers (1 pack)
- popsicle sticks (1 pack)
- Straws (1 pack)
- Blind fold (bandana?) (1)
- iPads
- Box fan (1)
- Extension cord (1)
- Wax paper (1 roll)
- Plain computer paper (20 sheets)

D) TEACHER CONTENT KNOWLEDGE

1. We need to know how different animals communicate, specifically in water
    a. SONAR-Sound Navigation And Ranging, is the process of listening to specific sounds to determine where objects are located
    b. Echolocation-A method used to detect objects by producing a specific sound and listening for its echo
2. We need to know how humans have adopted this technology (biomimicry)
    a. Underwater sonar devices to find objects
    b. Airplanes
3. We need to understand locomotion
    a. Locomotion - movement or the ability to move from one place to another
        i. Structure
        ii. Webbed feet
        iii. Jellyfish structure
        iv. Fins (paddles)

4. We need to know what part of a boat's structure is inspired by nature
    a. The outside of the boat is inspired by the scales of a fish (reduces friction)
    b. Shape of boat is fairly similar to the shape a fish

E) REFERENCES (list **ALL** references that you borrowed ideas from to develop this lesson – including any handouts you may distribute)
Handout:
https://docs.google.com/document/d/1wUX8CsaZHe8O5EIrZ3LQfGKz8O32_-O4CLfAxCGvW60/edit

F) TENTATIVE TIMELINE
9:30-10:00 BatMoth Game and Debrief

- Play BatMoth Game in the atrium
- Debrief by asking students questions to guide them towards discussing and understanding communication through echolocation/SONAR

10:00-11:00 Boat Building Challenge

- Students will brainstorm boat designs in their small groups
- Using materials in the classroom, the groups will build their boats
- Once the groups are finished, we will have the students send their boats down a (water bin*)
- Compare and contrast boat structures and materials/discuss what each group could adjust to improve their boat
- Connect boats with the concept of biomimicry and SONAR
- Locomotion discussion (Structure, Webbed feet, Jellyfish structure, Fins (paddles))

11:00-11:15 Snack
11:15-12:00 Introduce Final Project

- In depth explanation of final project, introduce the different problems they can choose from (transportation, shelter, impact forces)
- Groups will choose their problem, brainstorm how they might solve it
- Once they have chosen a problem, groups will use iPads to begin researching their problem and ideas for a solution
- They will then travel to the MILL to see what materials/machines they could use to create their invention that solves their chosen problem
- After returning they will begin to fill out the worksheet that explains their final invention

G) DESCRIPTION OF YOUR LESSON

ENGAGE

- BatMoth Game
    - Bring children to the atrium or outside (depending on how cold it is)
        - The students form a circle
        - One student is designated as the bat
        - Another student is designated as the moth
        - The bat begins by calling out "bat"
        - The moth does not say anything until the bat says "bat"
        - Once they hear them say "bat" they reply "moth"
        - This continues until the bat finds the moth in the circle
    - Debrief questions
        - How did the bat figure out where the moth was?
        - When could the moth respond?
        - How does this relate to how bats actually navigate the world?
        - What other animals can we think of that navigate this way?
            - Bats
            - Dolphins
            - Whales
        - How have humans adopted this technology?
            - SONAR (boats/fishing)
            - Robots use this to navigate
            - Airport security

EXPLORE

- Building Boats Challenge
    - Focus on mimicking a dolphin or shark --- ***shape*** and ***surface*** (so like a torpedo and smooth)
    - Students will split up into groups of 2 or 3
    - They will be given time to brainstorm how to create/design a boat/vessel base that goes the farthest in the shortest amount of time
        - Materials will be provided
        - They will be given/or create the same mast

        - They will be given time to create the shape of their boat and the material that is the surface of the boat
        - After building we will have them time their boats as they go down the (water bin)*
        - Record the time and how long it stays upright for
        - Compare and contrast boat structures and materials
        - Discuss how they can improve their boat after this discussion
    - Connect boats and biomimicry
        - Shark/fish scales
- Debriefing Questions:
    - What did you notice about what made a boat move faster or slower?
    - How did the type of materials used impact travel time?
    - How does stability impact an object's ability to travel a certain distance?
    - What part of a boat's structure/design is inspired by nature? How? Why?
    - Why did we have you use the same type of mast?

EXPLAIN

- Ask students to explain why we might want to mimic the use of echolocation by animals (This connects back to the BatMoth game that was played in the Engage section and should be asked immediately after).
    - This is how we developed sonar
    - Can help boats locate things under water as they navigate
    - Helps fishermen determine where there are a lot of fish
    - Robots have used this when moving around to know where they are as their "eyes"
    - Security scanners at the airport use this type of technology to "see" what you have
- Ask students to explain why we might want to mimic the features of different aquatic animals when building boats
    - This helps them travel more efficiently
    - Makes our boats go faster
    - Shape can help cut through the water

○ Material can help movement through the water go smoother
ELABORATION ● Introduce Final Project ○ In depth explanation of final project, introduce the different problems they can choose from ○ Groups will choose their problem, brainstorm how they might solve it ○ Once they have chosen a problem, groups will use iPads to begin researching their problem and ideas for a solution ○ They will then travel to the MILL to see what materials/machines they could use to create their invention that solves their chosen problem ○ After returning they will begin to fill out the worksheet that explains their final invention

H) EMBEDDED FORMATIVE ASSESSMENT (the 5th "E")

- Creating boats
- Creating that connection between boats and aspects in nature

I) GEARING UP/GEARING DOWN

1. Gearing up:

- For BatMoth game, if they are finding the "moth" too quickly and it is not challenging enough we can have them expand the circle, as well as adding another moth
- The people creating the circle can also say "tree" when the bat says "bat"; more stimuli to absorb
- To make the boat challenge more difficult we can have them use a specific material to use or it has to be a specific weight

2. Gearing down:

- Provide assistance when needed (research, creating boats)

Final Project Ideas (Will introduce in week 3):

- Requirements:
  - 2 things inspired by nature/biomimicry
- Challenges:

- Structure
  - Draws on something from nature that gives strength or stability to the structure.
    - This can be tested by a) 500 mL of rain, wind (like a Hurricane) b) a 10 second flash flood
- Transportation
  - Must travel at least 25 feet
  - Must stay airborne for 7 seconds
- Open
  - What is something that has inspired you?
  - Can you identify a need that should be addressed ?
  - Is there a specific aspect of nature you see applicable somewhere?

Q405 Saturday Science Teaching – Fall 2017
Lesson Plan #4

Biomimicry and the Aquatic World

Beavers and Their Dams

GRADE 6-8

A) LEARNING OBJECTIVES and CRITERIA FOR DETERMINING IF OBJECTIVES ARE MET (minimum of 2/ lesson)

1. Students will be able to identify the benefits of a dam
2. Students will be able to identify why humans have taken this structure and adapted it for our own use

B) STANDARDS (see http://www.doe.in.gov/standards/science)

- **Science and Engineering Process Standards:**

SEPS.1 Posing questions (for science) and defining problems (for engineering)

SEPS.2 Developing and using models and tools

SEPS.3 Constructing and performing investigations

SEPS.4 Analyzing and interpreting Data

SEPS.5 Using mathematics and computational thinking

SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)

SEPS.8 Obtaining, evaluating, and communicating information

- **Content Standards:**

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem.

6-8.E.3 Analyze data from investigations 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.

6-8.E.4 Develop a prototype to generate data for repeated investigations and modify a proposed object, tool, or process such that an optimal design can be achieved.

C) MATERIALS (**asterisk (*)** = any materials that may be a **safety concern**)

- Cardboard (6 large pieces of cardboard)
- Aluminum foil (1 roll)
- Saran Wrap (1 roll)
- Straws (1 pack)
- Popsicle sticks (1 pack)
- Pom poms (1 bag)
- Feathers (2 large bags)
- Markers (6 packs)
- Construction paper (1 pack)
- Tape (6 rolls of masking tape)
- Styrofoam(6 sheets, ½ inch thickness)
- Scissors (20 pairs)
- String/yarn (1 skein)
- Toothpicks (2 packs)
- Air dry clay (2 packs)
- Popsicle sticks (1 box)
- Plastic bottles (for dam design and final project)
- Assorted Plastic (for dam design)
- Clay
- Tissue paper
- Paper cups (5)
- Thin braided rope
- Elastic rope
- Cardboard box
- Piece of flat wood
- Lantern/flashlight
- Cloth
- Bins
- Pitchers to pour water

D) TEACHER CONTENT KNOWLEDGE

A dam is built to control water through placement of a blockage of earth, rock and/or concrete across a stream or river. Dams are usually constructed to store water in a reservoir, which is then used for a variety of applications such as irrigation and municipal water supplies. Reservoir water can also be directed to flow through hydraulic turbines, producing electric power for use in homes and industries. Hydroelectric power is considered a renewable source of energy because the reservoir water that is used to generate electricity is continuously replenished. A dam using locks and canals, such as the series of locks on the Panama Canal, enables navigation through a human-made water route that must overcome elevation differences.
The disadvantages of dams include the resulting flooding of large areas of land (destroying flora and fauna), altering the physical characteristics of the river below the dam (also affecting flora and fauna), impeding fish migration, and killing large numbers of fish that pass through hydroelectric turbines. In recent years, engineers and scientists have begun to manage reservoirs and their releases to be less harmful to aquatic and terrestrial wildlife and plants, as well as humans residing below the dam—a method of water resource management called adaptive management.

E) REFERENCES (list **ALL** references that you borrowed ideas from to develop this lesson – including any handouts you may distribute)

https://www.teachengineering.org/lessons/view/cub_dams_lesson01
https://www.youtube.com/watch?v=yJjaQExOPPY

F) TENTATIVE TIMELINE

9:30-9:45 Beaver Dam Video

- Show PBS Beaver video and have short class discussion asking what they noticed about the materials used, general structure, and purpose of a beaver dam

9:45-10:45 Introduction of beaver dam challenge

- Introduce students to the challenge
- Provide them time to build their dam and test it
- Discuss what works and revise based on class discussion

10:45-11:00 Snack

11:00-12:00 Final project

- Review final projects
- Review what materials are needed
- Start building and testing projects

G) DESCRIPTION OF YOUR LESSON

ENGAGE

Begin by showing class this video of beavers building dams:
https://www.youtube.com/watch?v=yJjaQExOPPY

- Questions
  - What did you notice from the video?
  - What did you notice about the construction of the dam
  - What did the beavers use to make their dam?
  - How were each of the materials used?
  - What is purpose of building these dams?

EXPLORE

Beaver dam: we have actually taken the structure of the dam and adapted the idea and design for our benefit

Frame the challenge of building a beaver dam.

Beavers build their **dams** to create a pond of deep, quiet water, where they can **build** their home or lodge. The dam slows down the flow of the river, so that the **beavers**' home does not wash away.

Because of the dramatic effects their dams have on surrounding ecosystems, these mammals are considered a keystone species. By constructing dams they create wetlands -- lush environments which attract fish, ducks, frogs and other creatures.

Why do humans use dams?

Reservoirs **created** by **dams** not only suppress floods but also provide water for activities such as irrigation, **human** consumption, industrial use, aquaculture, and navigability. Hydropower is often used in conjunction with **dams** to generate electricity.

Challenge:

You are going to be civil engineers working for the company Splash Engineering. Your main client is the government (also known as a "municipality") of Thirsty County. The government of Thirsty County has been receiving complaints from its residents over the last decade. The main problems include:

- Not enough water for people during the summer droughts.

- Farmers have trouble growing food without enough irrigation water.
- During drought periods, the Birdseye River is not deep enough for ships to cross to bring valuable goods to Thirsty County.
- Flash floods ruin houses and stores.
- Air pollution from a nearby coal-fired power plant makes people sick.

The Thirsty County government has hired the Splash Engineering firm (your class) to study the needs of the community and develop a solution that addresses those needs.

Questions:

1. Why do we create dams?
2. What are similarities/difference between a beaver dam and human made dam?
3. What do you think humans made certain adaptations to the beaver dam?
4. What are some issues that may arise when creating a human made dam?
5. What aspects of beaver dams did you use in the construction of your dam? Why?
6. What problems could we as humans run into if we did not use beaver dams as inspiration to create human made dams?

EXPLAIN

-After students have built their beaver dams there will be a discussion about how they were constructed. Students should be able to answer what materials they built with, how they constructed their dam, and why they built it the way they did. Finally, students should explain how the beaver dams directly inspired their own dams and how they used parts of the beaver dam to build their own.
-After students test their dams, they should explain what worked well and how their dam succeeded, and where their dam struggled to perform. Students should analyze how they might be able to improve their dam to work better and try to fix problems they encountered during the first trial run.
-After fixing their dam and testing it a second time, students should explain what changes they made to their dam and why. They should again explain how they have drawn inspiration from beaver dams and why/how their changes improved upon their original construction.

ELABORATION

-Students will be given time for the rest of class to work on their final project. At the end of last week, all students should have come up with a preliminary plan about what challenge they will be doing and how they plan on doing it. This week, we will be meeting with each group and asking them to elaborate on how they plan to actually construct their invention for the final project. Students will need to have concrete ideas about how they plan to construct their invention and what materials they need. For the rest of class, students will continue the construction of their final project.

H) EMBEDDED FORMATIVE ASSESSMENT (the 5th "E")

- Creating dam and explaining connection between a beaver dam and human made dams
- Questions listed in the explore phase
    - Why do we create dams?
    - What are similarities/difference between a beaver dam and human made dam?
    - What do you think humans made certain adaptations to the beaver dam?
    - What are some issues that may arise when creating a human made dam?
    - What aspects of beaver dams did you use in the construction of your dam? Why?
    - What problems could we as humans run into if we did not use beaver dams as inspiration to create human made dams?

I) GEARING UP/GEARING DOWN

1. **Gearing up:** If building their dam is too easy, we can ask students to try and build a dam again using materials more closely related to what a beaver would use. We will limit their materials to popsicle sticks, clay/play-doh, toothpicks, and straws.
2. **Gearing down:** For groups that are struggling, we can sit down and have a conversation with them about what materials beavers use to build their dams. From there, we can try to help them understand the connection between that and what materials we have available that mimic what the beavers were using. When it is time to test, we can use less water so that their dam does not need to be quite as strong. Then to ensure that they are still getting the same information, we can talk about how they might have strengthened their dam to make it better.

(Insert any handouts here)

Q405 Saturday Science Teaching – Fall 2017
Lesson Plan #5

Nature Inspiration

Insulation and Waterproofing: Biomimicry and Staying Warm

GRADE LEVELS 6-8

A) LEARNING OBJECTIVES and CRITERIA FOR DETERMINING IF OBJECTIVES ARE MET (minimum of 2/ lesson)

1. Students will be able to explain what insulation is
2. Students will be able to provide examples of where insulation is present in nature
3. Students will be able to understand what materials are best for insulation
4. Students will be able to solve one of the final projects challenges
5. Students will be able to apply two aspects of biomimicry to the invention they have created

B) STANDARDS (see http://www.doe.in.gov/standards/science)

- **Science and Engineering Process Standards:**

SEPS.1 Posing questions (for science) and defining problems (for engineering)

SEPS.2 Developing and using models and tools

SEPS.3 Constructing and performing investigations

SEPS.4 Analyzing and interpreting Data

SEPS.5 Using mathematics and computational thinking

SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)

SEPS.8 Obtaining, evaluating, and communicating information

- **Content Standards:**

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem.

6-8.E.3 Analyze data from investigations 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.

6-8.E.4 Develop a prototype to generate data for repeated investigations and modify a proposed object, tool, or process such that an optimal design can be achieved.

C) MATERIALS (**asterisk (*)** = any materials that may be a **safety concern**)

- Cardboard (6 large pieces of cardboard)
- Aluminum foil (1 roll)
- Saran Wrap (1 roll)
- Straws (1 pack)
- Popsicle sticks (1 pack)
- Pom poms (1 bag)
- Feathers (2 large bags)
- Markers (6 packs)
- Construction paper (1 pack)
- Tape (6 rolls of masking tape)
- Styrofoam(6 sheets, ½ inch thickness)
- Scissors (20 pairs)
- String/yarn (1 skein)
- Toothpicks (2 packs)
- Air dry clay (2 packs)
- Popsicle sticks (1 box)
- Clay
- Tissue paper
- Paper cups (5)
- Thin braided rope
- Elastic rope
- Cardboard box
- Cloth
- Hot Plate

- Labquest (6)
- Temp probe (6)
- Black bin
- Watering can

D) TEACHER CONTENT KNOWLEDGE

1. Teachers need to have an understanding of what blubber is and how it helps keep animals warm (Blubber: thick layer of fat between an animal's skin and muscles)
2. Understand other forms of insulation we created that we have been inspired by animals (cooler, thermos, house, winter coat)
3. Understand how insulation works (traps air inside or blocks air outside), watch all of the videos beforehand
4. Understand what materials may best insulate the cup
5. How to heat up the water and take the temperature before and after
6. Understand how to use LabQuest thermometers and help the students out with the settings, etc.

E) REFERENCES (list **ALL** references that you borrowed ideas from to develop this lesson – including any handouts you may distribute)

How Do Whales, Polar Bears, and Penguins Keep Warm?
https://youtu.be/TwfKCX_8fbA
Animals With Winter Coats
https://www.youtube.com/watch?v=0N7FGPeykfE
Insulation Explained With Some Help From Coffee Cups
https://www.youtube.com/watch?v=E2_BI-qg5Bw
How Do Wetsuits Keep You Warm?
https://youtu.be/6B05sU20-Jw

F) TENTATIVE TIMELINE

9:30-9:40 Discuss different forms of insulation that we use as humans.

- Winter coats, house insulation, cooler insulation, thermos insulation, etc.
- Discuss how we may have gotten these ideas from animals (biomimicry)

9:40-9:50 Show videos:

a) https://www.youtube.com/watch?v=0N7FGPeykfE
b) https://www.youtube.com/watch?v=TwfKCX_8fbA

9:50-9:55 Introduce Insulation Challenge

- Tell students they will be insulating their own cup of hot water. They must use what they have learned from the videos and the materials we have brought in to create an insulation for their cup.

9:55-10:05 Insulation Challenge

- Give students 10 minutes to work with their table group and insulate their cup.

10:05-10:15 Pour water in cups and wait for cool down

- Take initial temperature of water and take temperature again after ten minutes.
- Show them the two videos about insulation

https://www.youtube.com/watch?v=E2_BI-qg5Bw
https://youtu.be/6B05sU20-Jw

- Begin instructions about what the rest of the day will be (final project building, testing, and explanations)

10:15-10:25 Take final temperatures and do debrief discussion

10:25- 10:35 Snack

10:35- 11:15 Finish up working on their final projects

11:15- 11:45 Test final projects

11:45-12:00 Debrief discussion about final projects

G) DESCRIPTION OF YOUR LESSON

ENGAGE
- Begin with discussion on what things help keep us warm (insulation in houses, thermoses, coats)
  - How are these things made?
  - What materials in these things help keep us warm?
-Show video on how whales, polar bears, and penguins keep warm: https://youtu.be/TwfKCX_8fbA
- Then, show video on "Animals with Winter Coats": https://www.youtube.com/watch?v=0N7FGPeykfE

EXPLORE -Students will have an "insulation challenge" where they need to find the best way to insulate a plastic cup full of warm water. ● Give students an empty plastic cup

- They have 10 minutes to cover the cup in whatever way they think will be the most effective and keep in the most heat.
- Fill the cups with warm water and take the initial temperature.
    - There should be one uninsulated cup that is also filled with water to serve as a control
- Wait 10 minutes and then take the temperature of the cups again
    - Show them: https://www.youtube.com/watch?v=E2_BI-qg5Bw while they are waiting
    - Also show them this: https://youtu.be/6B05sU20-Jw
- Have students calculate the difference in temperature.
- Finish with the discussion in the explain section

-Final project work time

- Give students time to finish working on the construction of their final projects

EXPLAIN

-Finish the cup insulation exploration with a debrief discussion explaining what materials worked well, what didn't work well, and why we want to adopt the ways that animals insulate themselves

Questions:

1. Why have we adopted this idea of insulation?
2. Where do we see this idea of insulation in our day to day lives?
3. How would we be affected if we did not adopt this?
4. How have we modified insulation for human use?

-Final project explanation

- Have all students explain what their final project is.
    a. What is it?
    b. What problem does it solve?
    c. What aspects of biomimicry do you have?
- Test each individual project

ELABORATION

-Discussion about final projects

- What worked well with your project?
- What didn't work?
- What aspects of biomimicry helped or hurt your final project?
- If you could change it, what changes would you make?

H) EMBEDDED FORMATIVE ASSESSMENT (the 5th "E")

-Questions to ask about cup insulation challenge:

1. Why have we adopted this idea of insulation?
2. Where do we see this idea of insulation in our day to day lives?
3. How would we be affected if we did not adopt this?
4. How have we modified insulation for human use?

-Questions to ask about their final projects:

1. What is it?
2. What problem does it solve?
3. What aspects of biomimicry do you have?
4. What worked well with your project?
5. What didn't work?
6. What aspects of biomimicry helped or hurt your final project?
7. If you could change it, what changes would you make?

I) GEARING UP/GEARING DOWN

1. Gearing up:

To gear this lesson up, we could restrict the amount of materials students have to insulate their cup. We could limit them to feathers, cotton, and animal fur samples that we have. This would more closely replicate actually mimicking what animals have and use to insulate themselves and stay warm.

2. Gearing down:

To gear this lesson down, we will go to individual groups and help them build their cups with insulation.

(Insert any handouts here)