5E Lesson Plan

Title: Waves and Information Transfer

Summary:
Students will experiment with binary code (a system of zeroes and ones) to send a message using light and sound. Once they have sent the code, they will evaluate the methods to see if they were successful in sending the message and which was easiest to use.

Author: Ms. Davis – Central University STEM Center (blinded for review)

Grade level: 4th Grade

NGSS Connections:

Performance Expectation

4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.*

[Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-PS4-3)

Disciplinary Core Ideas

PS4.C: Information Technologies and Instrumentation

- Digitized information transmitted over long distances without significant degradation. High tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)

ETS1.C: Optimizing The Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (secondary to 4-PS4-3)

Cross Cutting Concepts

Patterns

- Similarities and differences in patterns can be used to sort and classify designed products. (4-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

Knowledge of relevant scientific concepts and research findings is important in engineering. (4-PS4-3)

Materials:

Engage:

- Bongos or other small drum
- Magic light bulb – lights up when resting on hand
- Magnifying loupes for each student

- Engaging with Pixels for each student (attached, created by STEM Center staff)

Explore:

- Tri-fold boards (Handmade display/visual aids created by STEM Center staff. Photos available upon request.):
- Sound Off Learning Target board
- Miniature tri-board + materials cards
- Intermediate Ranking Full Group Formative Assessment tri-board + light & sound option cards

- For each group: Ring of O, 1 letter cards (handmade by STEM Center staff; contact authors for more information.)
- Scaffolded science notebook for each student (handmade by STEM Center staff)
- Various materials to test + pictures of each possibility to put in the miniature tri-board below (examples):
- Battery operated tea lights
- Dowel rods
- Cups and rubber bands
- Flashlight and colored lenses
- Clapping hands
- Clapping hands that light up
- Bells
- Laser and opaque piece of cardboard
- 2 different colors of glow sticks
- Energy ball or other light up toy
- Energy tubes

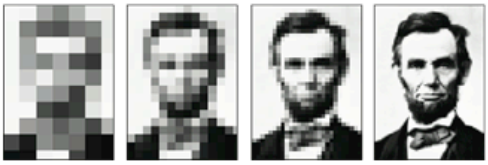
Learning Target(s):
I can generate and compare multiple solutions that use patterns to transfer information.

ENGAGEMENT

- Describe how the teacher will capture students' interest.
- What kind of questions should the students ask themselves after the engagement?

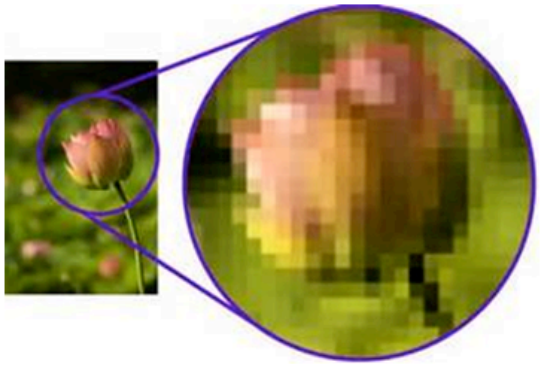
1. Have "Engaging with Pixels" article on student desks as they arrive. Discuss page 1.
2. Once they have finished reading the sections, model how to use the "Private Eye." Have them return to the page and look more closely at the images.

All of our TV, computer, and cell phone images are composed of tiny picture elements called "pixels." The more pixels there are the sharper the image. For example consider the following images of the same photo, but made with fewer pixels on the left and more pixels on the right.



Use your "Private Eye" to look at the dots.

You can use a high power magnifier to see these on a computer or TV screen. Each dot will be a color made of up of one or more of three colors. What are the three colors? Red, green, and blue (RGB)! A pixel is the zeroes and ones that represent the digital information. Look at the image below.



Use your "Private Eye" to look at the image.

3. Distribute the Science Notebooks to students. Have them fill out the name, date, and time for today's class.

4. Tell the students to turn the second side of "Engaging with Pixels", page 2. Share the information with them.

Radio Telescope: Wikipedia Commons

SETI, the Search for Extraterrestrial Intelligence, is a scientific research project in which scientists "listen" for radio or light signals that might be sent by other intelligent beings in the universe. One of the search strategies is to figure out how a string of dots and dashes, or ones and zeros, could be interpreted as a picture—perhaps of the life forms themselves. Such a string could be made visible if the ones were dark pixels and the zeros were light pixels. But how would we know when one line ends and one begins?

Dr. Jill Tarter, Chief Scientist, SETI Institute

courtesy of SETI Institute

Can you use a code of zeros and ones to decode a message from me using light and sound?

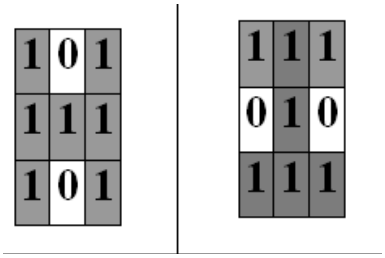
In your Science Notebooks, shade in the boxes with your pencil. Each box contains one letter. What is the message I was sending you?

5. To engage further, hold the magic light bulb in your hand so that it lights up without having to be

plugged in to a socket. Ask the students what they notice. Demonstrate turning the light bulb "on and off" by tapping it on your palm (facing up). Tell them that you are sending a signal to them. Ask if they know what it says. Ask why they don't know. Tell them that you can teach them to decode your message simply.

6. Tell students you are going to use a code of zeros and ones to send them a message with sound and/or light, or both at the same time.

Show them how to use the grid in their Science Notebooks to record the letters by having them fill in the word HI (meaning hello) while you send the message with sound and/or light. (I use bongo drums to send sound waves: 1 beat = 1, 2 beats = 0). Tell them that you will pause between beats and count to 5 so that they can distinguish between the boxes and that they will be shading in the boxes from left to right, starting with the top row.



To help you remember the code:

Bongos (Sound)

1	2	1
1	1	1
1	2	1

Magic Bulb (Light)

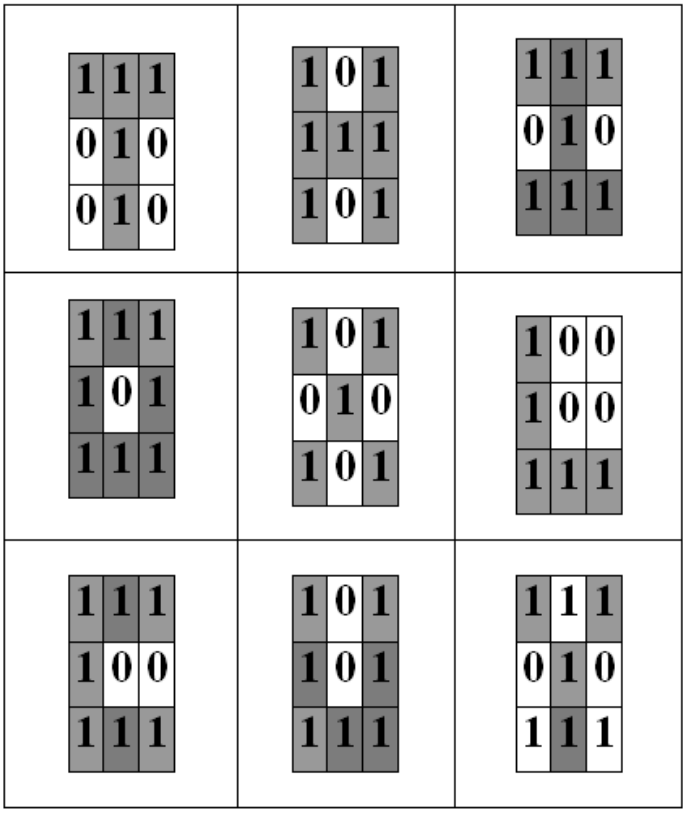
1	1	1
2	1	2
1	1	1

"What is the message I was sending you?"

EXPLORATION

- Describe what hands-on/minds-on activities students will be doing.
- List "big idea" conceptual questions the teacher will use to encourage and/or focus students' exploration

1. Give students instructions to begin the exploration by saying, "Your task is to work with your team to transfer data across the room using ones and zeros. Show the students the ring of digital signals.



2. Distribute the bag with various materials to the students. Have them work in teams to decide on 2 methods (sound or light) for sending the message. Once the methods are decided, students pair up as team one and team two. The pair that is team one will stay on one side of the classroom and create a message and send it. The pair that is team two will go to the other side of the classroom and try to receive the message. SAFETY NOTE: *Students are asked to not shine lights in each other's eyes or directly toward each other, but to send the signal onto a wall. The "team two" student – the receiver – will look to the space on the wall, not directly at the sender.*

> **Team One:** You may either send a letter, an acronym (like LOL, OK) or a word (TOY, CUT) – **let the students come up with the possibilities**. Shade in the letters or words you will be sending. Send the message.
>
> **Team Two:** Write the numbers in as you receive them from your team. Shade in the numbers in your notebooks when the message stops.

3. Have students join their team and rank their results using their mini-tri-boards and the cards provided. They will decide on which type of message was the most successful and why. These notes will be written in their student notebooks. This will serve for them to share results in the explanation phase. The following prompts for student thinking are in the scaffolded student notebooks:

Which materials did you use to send your information for this experiment?

Were you successful in sending your message? Why or why not?

Which of your systems did you prefer and why?
(Rank #1 as the most and #2 as the least)

EXPLANATION

- Student explanations should precede introduction of terms or explanations by the teacher. What questions or techniques will the teacher use to help students connect their exploration to the concept under examination?
- List higher order thinking questions which teachers will use to solicit *student* explanations and help them to justify their explanations.

1. Have students share their miniature tri-boards with the class. Ask questions like:
   - Was a pattern used in all communications? How so? Can you describe those patterns?
   - Sound and light are two different kinds of waves. How do they communicate information?

2. Review the learning target using the "Sound Off on Your Learning Target" Tri-board:
   "I can generate and compare multiple solutions that use patterns to transfer information."

3. Have a whole group discussion about this learning target. Were you successful? How do you know?

ELABORATION

- Describe how students will develop a more sophisticated understanding of the concept.
- What vocabulary will be introduced and how will it connect to students' observations?
- How is this knowledge applied in our daily lives?

1. Whole group discussion: Are there other patterns besides 0 and 1? Have students brainstorm and try out other patterns. See the attached "Patterns in Coding" folder for ideas. Once completed, use the attached "Data Transfer Rubric" that includes a third column, making patterns.
2. Discuss Morse Code and technology. Have students practice these codes with each other.

Technology Connection:

Discussion: In 1836, Samuel E.B. Morse built the first working telegraph. He also devised a code that permitted telegraph operators to exchange information. His code is still used by telegraph, radio and signal light operators. Listed below is The International Morse Code.

Morse Code Letters and Numbers:

 A	 B	 C	 D	E	 F
 G	 H	 I	 J	K	 L
M	N	O	 P	 Q	 R
 S	T	 U	 V	 W	 X
 Y	 Z	0 (zero)	1 (one)	 2	 3
 4	 5	 6	 7	 8	

Discuss: Think of the code as sound, not dots and dashes. Have students say "dit" for dot and "dah" for dash. Thus A is "ditdah" or "didah", B is Dahdididit, etc. Use the International Morse Code and have students create messages to send to each other. Talk abot how Morse Code Translator (very fast) – can send messages via e-mail, Facebook, etc.

ELA Connection

Source:

The Science and Technology of Sound, Emily Morgan & Karen Ansberry, *Science & Children*, NSTA, February, 2014

Purpose:

This article is cited as an elaboration within the lesson plan for "Communication and Information Transfer" for participating teachers to visit the NSTA website to see a resource that connects to the lesson presented. The intermediate section of this lesson plan uses the informational text Secrets of Sound: Studying the Calls and Songs of Whales, Elephants, and Birds (Scientists in the Field), April Pulley Sayre, Houghton Mifflin, 2002. To summarize the intermediate portion of the lesson, "Animal Sounds", grade 4 students explore bioacousticians (scientists who study the sounds of living things). While the students explore finding key information and details from the text on whales, during the evaluation, they create a three column brochure where they draw and label the structures of a chosen animal, draw and label the structures of that animal that detect sound, and explain how the animal uses sound to interact with other animals and its environment.

Common Core ELA Reading standards based on informational text and language standards addressed for 4th grade in the article:

1. Key Ideas and Details
    - Refer to details and examples in a text when explaining what the text says explicitly and when

drawing inferences from the text.

2. Integration of Knowledge and Ideas
   - Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on web pages) and explain how the information contributes to an understanding of the text in which it appears.
3. Vocabulary Acquisition and Use
   - Determine or clarify the meaning of unknown and multiple meaning word and phrases based on grade 4 reading, choosing flexibly from a range of strategies.
4. Writing across all content areas is emphasized within the Common Core

Social Studies Connection

Have students research the history of communication and create a timeline.

EVALUATION

- How will students demonstrate that they have achieved the lesson objective?
- This should be embedded throughout the lesson as well as at the end of the lesson

1. Give each student a post-it note. Have them number 1, 2, and 3 on the post-it. Ask students how they would rank sending waves using sound, using light, or using sound and light after seeing all of the presentations. Have them put each post-it on the full group ranking tri-board with the word of their first choice.

Generate and Compare Multiple Solutions That Use Patterns to Transfer Information Rubric

	4	3	2	1
Performance	Students developed two systems to deliver their message. The message was delivered successfully.	Students developed two systems to deliver their message. The message was not transferred correctly.	Students developed one system and the message was sent correctly.	Students developed a single system. The message was not sent or was decoded incorrectly.
Explanation	Students clearly compare and contrast their systems and give reasons on which system they liked best.	The students give their preference, they attempt to explain, but do not clearly explain why it was the best.	The students say what their preference was, but give no reasons why.	The students did not explain which system they preferred.

DIFFERENTIATION: Identify differentiation strategies used in the fishbowl:

- Flexible grouping
- Authentic and alternative assessments
- Cooperative learning
- Multimedia

- Learning contracts
- Inquiry
- Learning stations / centers
- Problem – based learning
- Tiered assignments
- Science notebooks to record as scientists in ways that are meaningful for the individual learner
- Independent study
- Direct instruction

RELATED LITERATURE

Sending Messages with Light and Sound, Jennifer Boothroyd, Lerner Classroom, 2014
What are Light Waves?, Robin Johnson, Crabtree Publishing, 2014
What are Sound Waves?, Robin Johnson, Crabtree Publishing, 2014
How Does Sound Change?, Robin Johnson, Crabtree Publishing, 2014
Audio Engineering and the Science of Waves, Anne Rooney, Crabtree Publ. Co., 2014
Optical Engineering and the Science of Light, Anne Rooney, Crabtree Publ. Co., 2014