Beyond the Slinky®, Part 3

Information Transmission Through Waves

Heather Shaffery, Danny Mattox, Alex Parsons
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Grade Level	6th – 8th Grade	**Time Frame**	180 minutes
Subject	Science	**Duration**	3-4 class periods

Essential Question

How does the use of more complex wave patterns affect the communication of audiovisual messages?

Summary

Students will investigate how digital and analog waves carry information by developing a model and relating it to information transmission. This lesson is Part 3 of "Beyond the Slinky®," a three-part lesson series on waves and their properties.

Snapshot

Engage

Students watch a video about the evolution of video games over the past 40 years.

Explore

Using the long, snaky spring from the Part 2 lesson, students develop a model for sending analog and digital signals. Using the model, students also send low-resolution images with waves.

Explain

Students talk about their models and their relationship to real waves. Students also compare the efficiency of digital signals with that of analog signals.

Extend

Students send higher-resolution images using their snaky spring models and discuss the practical difficulties of sending complex information via waves.

Evaluate

Using the Claim, Evidence, Reasoning (CER) strategy, students explain why the video games from the Engage portion looked better over time. They compare their explanations with their understanding from the beginning of the lesson.

Standards

Next Generation Science Standards (Grades 6, 7, 8)

MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

Oklahoma Academic Standards (8th Grade)

8.PS4.3 : Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.*
8.PS4.3.1: Many modern communications devices use digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

Attachments

- Claim Evidence Reasoning CER—Beyond the Slinky® Part 3 - Spanish.docx
- Claim Evidence Reasoning CER—Beyond the Slinky® Part 3 - Spanish.pdf
- Claim Evidence Reasoning CER—Beyond the Slinky® Part 3.docx
- Claim Evidence Reasoning CER—Beyond the Slinky® Part 3.pdf
- Content Assessment Guide—Beyond the Slinky® Part 3.pdf
- Explain—Beyond the Slinky® Part 3 - Spanish.docx
- Explain—Beyond the Slinky® Part 3 - Spanish.pdf
- Explain—Beyond the Slinky® Part 3.docx
- Explain—Beyond the Slinky® Part 3.pdf
- Explore 3x3—Beyond the Slinky® Part 3 - Spanish.docx
- Explore 3x3—Beyond the Slinky® Part 3 - Spanish.pdf
- Explore 3x3—Beyond the Slinky® Part 3.docx
- Explore 3x3—Beyond the Slinky® Part 3.pdf
- Extend 5x5—Beyond the Slinky® Part 3 - Spanish.docx
- Extend 5x5—Beyond the Slinky® Part 3 - Spanish.pdf
- Extend 5x5—Beyond the Slinky® Part 3.docx
- Extend 5x5—Beyond the Slinky® Part 3.pdf
- I Notice I Wonder—Beyond the Slinky® Part 3 - Spanish.docx
- I Notice I Wonder—Beyond the Slinky® Part 3 - Spanish.pdf
- I Notice I Wonder—Beyond the Slinky® Part 3.docx
- I Notice I Wonder—Beyond the Slinky® Part 3.pdf
- Lesson Slides—Beyond the Slinky® Part 3.pptx
- Spring Cards Blue—Beyond the Slinky® Part 3.pdf
- Spring Cards Orange—Beyond the Slinky® Part 3.pdf
- Spring Cards Red—Beyond the Slinky® Part 3.pdf
- Spring Cards Yellow—Beyond the Slinky® Part 3.pdf
- Template for Spring Cards—Beyond the Slinky® Part 3.docx
- Template for Spring Cards—Beyond the Slinky® Part 3.pdf

Materials

- Lesson Slides (attached)
- I Notice, I Wonder handout (attached; one per student)
- Claim, Evidence, Reasoning (CER) handout (attached; one per student)
- Template for Spring Cards (attached)
- Spring Cards Blue (attached; one card per group)
- Spring Cards Orange (attached; one card per group)
- Spring Cards Red (attached; one card per group)
- Spring Cards Yellow (attached; one card per group)

- Explain handout (attached; one per student)
- Explore 3x3 grids (attached; one half-sheet per group)
- Extend 5x5 grids (attached; one half-sheet per group)
- Content Assessment Guide (attached; for teacher use)
- Snaky springs (one per group)

Engage

Teacher's Note: Lesson Order

The order of this lesson is as follows: Engage, Explore 1, Explain 1, Explore 2, Explain 2, Extend, Evaluate.

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to share the essential question and go to **slide 4** to review the lesson objectives with students.

Go to **slide 5** and pass out the attached **I Notice, I Wonder** handout to each student.

Alternative to Printing the Handout

If you would like an alternative to printing the provided handout, you may have students write their observations and questions in their notebooks.

Then, show students the "Videogame Quality Phenomenon" video about the evolution of video games. Have students use the I Notice, I Wonder strategy to write their observations from the video and questions they have or things that pique their curiosity.

Embedded video
https://youtube.com/watch?v=mXq0totmYCg

Have a few students share out their observations and questions. Discuss the major ideas as a class.

Sample Student Observations

Students should notice that video game resolution has improved drastically over time.

Next, pass out the attached **Claim, Evidence, Reasoning (CER)** handout to each student. Ask students to write an initial explanation in response to the question, "Why do video game graphics improve over time?" on the handout.

After giving students time to write their answers, go to **slide 6**. Inform students that everyone's electronic devices send and receive information using electromagnetic (EM) waves, and they will explore how this works using a snaky spring model.

Teacher's Note: Prior Knowledge

The EM spectrum was covered previously in Part 1 of the "Beyond the Slinky®" lesson series, and the snaky spring model was used in the Part 2 lesson.

Go to **slide 7** and have students get in groups of four. Have students practice performing their group roles before beginning the formal Explore activities. Detailed guidelines for group roles are provided.

Explore 1

Teacher's Note: Modeling Analog and Digital Signals

In this section, students use long, snaky springs to model analog signals (Activity 1) and digital signals (Activity 2).

Display **slide 8**. Pass out the attached **Spring Cards** to student groups. Make sure each group has four cards—one of each color.

For Activity 1, have students send their signals by generating waves with the snaky springs without pausing between waves (i.e., continuously). Since students cannot pause between waves, they will have to decide on a way to differentiate between waves representing blank boxes and waves representing filled boxes (i.e., two different amplitudes).

Then, go to **slide 9**. Students should discuss the strengths and weaknesses of transmitting signals this way, paying particular attention to the difficulty of differentiating between analog waves. Invite students to think about how reliable their signals might or might not be if they could wait between signals instead of sending a constant stream.

Go to **slide 10.** For Activity 2, have students send their signals using discrete waves (i.e., pausing between waves). As they did in the first activity, students should send different signals for blank boxes vs. filled boxes.

Then, go to **slide 11**. Again, ask students to compare the strengths and weaknesses of transmitting signals this way. Most groups are likely to try sending blank boxes as silence/extended pauses between signals. They should consider if they could tell whether "silence" was a blank box, a missed signal on the part of the Receiver, or a delay by the Transmitter.

Explain 1

Teacher's Note: Discussing Analog and Digital Signals

In this section, students discuss the relative strengths and weaknesses of sending analog signals vs. digital signals and the relevant wave properties of each.

Display **slide 12**. To kick off the Explain discussion, have students compare the strengths and weaknesses of their signaling methods in Activity 1 vs. Activity 2. Next, use **slides 13 and 14** to define the types of signals they modeled: analog (Activity 1) and digital (Activity 2).

Teacher's Note: AM Radio vs. FM Radio

The "AM" in AM radio stands for "amplitude modulation," whereas "FM" stands for "frequency modulation." This means that AM stations are transmitted using analog signals, while FM stations are digital.

Ask students whether they have listened to AM stations before and how they differ from FM stations. If any students have, ask them to explain why FM stations are clearer than AM. (AM stations tend to have more static and unstable broadcasts because the signals are continuous.) This is not a necessary detail to include, but it is an easy potential connection to students' real-world experiences.

Go to **slide 15**. Review amplitude, wavelength, and frequency with students. They should have some familiarity with these features from prior experience—including Parts 1 and 2 of the "Beyond the Slinky®" lesson series, if they were used. Solicit students' ideas before providing explicit answers and/or direct instruction.

Go to **slide 16**. Ask students what part of the EM wave is relevant to analog signals (amplitude) and what is most relevant to digital signals (frequency). After the discussion, go to **slide 17** and formally reinforce the ideas students already came up with, or explain the information if they have not already discussed it.

Go to **slide 18** and pass out the attached **Explain** handout to each student. On the handout, ask students to answer the following prompt: "*Why are digital signals a more reliable way to send information than analog signals? Use evidence from your investigation and class discussion to support your answer.*"

Allow students to draw models and diagrams to support their answer.

Teacher's Note: Content Assessment Guide

See the attached **Content Assessment Guide** for an example of how you might assess students' responses to these two questions posed throughout the lesson:

1. Why are digital signals a more reliable way to send information than analog signals?
2. Why do video game graphics improve over time?

Explore 2

Teacher's Note: Sending Low-Resolution Images

In this section, students send a 3x3 image of a letter using their digital signal models.

Display **slide 19**. Once students have established the concept that digital signals are sent as a single wave pulse (1) or two wave pulses (0), they will create "low-resolution" images using digital signals.

Go to **slide 20**. Pass out the attached **Explore 3x3** grids and have students figure out how to send the message (i.e., the order in which the boxes should be signaled). Technically, their signals should be received/entered left to right from top to bottom, but it's okay if students come up with other methods at this point.

Explain 2

Teacher's Note: Discussing Image Resolution

In this section, students learn about pixels and their role in image resolution.

Display **slide 21**. As a class, discuss students' experience with sending low-resolution images and solicit their impressions and questions. If students have the prior knowledge to do so, have them develop a working definition for **resolution**. If they do not, provide the definition by clicking again on the slide.

Next, ask students how they think they could send a higher-resolution image. They should conclude that an image with more boxes (e.g., a 5x5 grid) would have a higher resolution.

Go to **slide 22**. This is an ideal time to stop and provide some direct instruction. Ask students for any prior knowledge they have about **pixels**. Reinforce any correct ideas they may already have and/or explain that each square in the grid represents a pixel.

Help students make the explicit connection between resolution and pixels by asking a guiding question, such as, "*How does the number of pixels affect image resolution?*" Students should come to understand that the more pixels an image has, the higher its resolution will be.

Extend

Display **slide 23**. Pass out the attached **Extend 5x5** grids and give students time to transmit a higher-resolution image using their spring models. They may draw their own images or send a 5x5 version of the letters they sent previously.

Teacher's Note: Time

If time is a concern, there are two alternatives to having students complete a 5x5 grid using the previous procedure. The second option is the least effective, but it would be sufficient as a last resort.

1. Have students try to send as many *recognizable* 1s and 0s as they can in a short amount of time. This would help them conceptualize the idea that computers can send large quantities of information very rapidly.
2. Students could do this as a paper-and-pencil activity by filling in both a 3x3 grid and a 5x5 grid for the same letter. This would help them conceptualize the idea that more complex images take longer to generate.

Optional Extension for Advanced Students

Have students create a 9x9 image and send the signal in 3x3 blocks.

Go to **slides 24–25**. Ask students to compare their experiences with sending 3x3 images vs. sending 5x5 images. Through discussion about the questions on slides 24 and 25, they should come to understand that sending complex information and visuals requires a greater number of EM wave signals, and that the process of sending and receiving them takes more time.

Go to **slide 26**. Discuss how computers and other electronic devices can send many digital signals very rapidly, which allows them to produce more complex images and videos.

Guiding Question

To further guide student learning, ask them how using an old computer or electronic device differs from using a newer one. (They're much slower, among other things.)

Evaluate

Display **slide 27**. Replay the video game evolution video from the beginning of the lesson.

Go to **slide 28** and ask students to return to the **Claim, Evidence, Reasoning (CER)** handout.

Have students use the Claim, Evidence, Reasoning (CER) strategy to explain how electromagnetic waves contribute to the change in video game quality. As before, allow students to draw models and diagrams to support their answers to the following questions:

1. Why do video game graphics improve over time? Use evidence and scientific information from your investigations and discussions to support your answer.
2. Look at the explanation you wrote the first time after you watched the video and compare it with your final explanation. In what ways did your thinking change? (In other words, what is different about your two answers?)

Resources

- K20 Center. (n.d.). Claim, evidence, reasoning (CER). Strategies. https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f506fc09
- K20 Center. (n.d.). I notice, I wonder. Strategies. https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f507d1a7
- Rishkon. (2019, July 24). Pixel cube [Image]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Pixel_Cube.png
- Shaffery, H. (2017, December 11). Videogame quality phenomenon [Video]. YouTube. https://www.youtube.com/watch?v=mXq0totmYCg&feature=youtu.be