

Unit 1: A Bit of Everything | Lesson 5

Sending Bits

Lesson time: 255 Minutes (5 days)

LESSON OVERVIEW:

In this lesson, students work in groups using common classroom supplies and everyday objects to develop their own systems for encoding and sending messages. Students will collaborate on an iterative project using a “maker ethos” to design a system for sending binary information from one place to another. Project ownership and team participation fosters student engagement. Several teaching strategies are suggested for pacing and encouraging students working in groups.

Did you know?

A maker ethos is the mindset or spirit of creative problem-solvers that includes imagination, inventiveness, inquiry, exploration, and analysis.

▶ Teaching Summary

Getting Started—15 minutes

1. Journal entry: What types of messages can be communicated with a single bit?
2. Introduce the sending bits challenge

Activity: Sending a one-bit message—65 minutes

3. Create a system to send simple one-bit messages
4. Test students' message systems
5. Class discussion
6. Journal entry: What binary messaging systems are used in this school?

Activity: Sending multiple bits—125 minutes

7. Sending more complex messages
8. Gallery walk: Demonstration of student message systems

Activity: Exploring real-world data transmission systems—75 min

9. Jigsaw learning activity

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COMPUTER SCIENCE PRINCIPLES LEARNING OBJECTIVES

- 1.1.1 Use computing tools and techniques to create artifacts.
- 1.1.2 Collaborate in the creation of computational artifacts.
- 1.2.1 Use computing tools and techniques for creative expression.
- 2.1.1 Describe the combination of abstractions used to represent data.
- 2.2.1 Develop an abstraction.
- 3.2.1 Use computing to facilitate exploration and the discovery of connections in information.
- 3.1.1 Use computers to process information to gain insight and knowledge.
- 3.3.1 Analyze the considerations involved in the computational manipulation of information.



A “maker ethos” learning environment is ideal for collaborative problem-solving experiences.

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Teaching Guide

MATERIALS, RESOURCES, AND PREPARATION

For the student

- Student journals
- Internet access
- One box of “maker supplies” for each student group, containing at least:
 - + Small flashlights
 - + Simple noisemakers such as bells, triangles, or whistles
 - + Cups and string
 - + Slinky
 - + Legos
 - + Colored paper

For the teacher

- Gather the maker supply collections

GETTING STARTED

1. Journal Entry

- Prompt students with: **“What types of messages can be communicated with a single bit? What characteristics do one-bit messages have? What messages would your classmates find useful that could be sent with one bit?”**
- If students do not come up with messages that can be communicated with a single bit, provide a few prompts: **“Was today’s homework collected?”**, **“Is there a pop-quiz?”**, or **“Do we have a substitute teacher today?”**
- Invite students to share their ideas with the class. Record the characteristics on the board or other display.

Teaching Tip

Engage students in analyzing the suggested messages according to the characteristics listed. Discard those that cannot be transmitted with one bit.

2. Introduce the sending bits challenge

- Create a messaging system using the maker supplies to send a one-bit message. If possible, use the ideas for one-bit messages that students suggested during the journal entry activity.

If students are having trouble deciding upon a message, here is an example: “Create a messaging system using the maker supplies to send a one-bit message to warn your classmates that there is a pop-quiz in class today.”

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ACTIVITY: SENDING A ONE-BIT MESSAGE—65 MIN**3. Creating a system to send simple one-bit messages (35 min)**

- Create groups of 3 to 4 students.

If possible, arrange for students to work at tables with adequate workspace and without computers. It is likely that another teacher would LOVE to trade a classroom for the computer lab for a few class periods.

- Introduce the Think-Make-Improve strategy

Open-ended activities can be challenging for students inexperienced with this learning strategy. Explicitly state that this problem does not have the “correct answer” students typically work for. Students are encouraged to define the problem as they wish.

Curriculum Connection

This activity can be linked to problem-solving and the candy bar problem in the ECS curriculum in which the definition of “break” led to a variety of solutions. If students are familiar with it, a short discussion of the results of that activity may be helpful.

- Provide students with the maker supplies

In an ideal setup, each group would have an identical collection of supplies. Alternatively, you could provide a large collection of supplies in the center of the room for groups to select from. In either case, it is important to reinforce that this is not a competition and that students should SHARE ideas between groups and feel comfortable asking questions of each other and the teacher.

Teaching Tip

An additional strategy to use in this activity is to designate a team “explorer.” Students in this role roam the classroom, observe what other teams are doing, offer suggestions, and report ideas back to their own teams. This is an effective way to reduce the competition.

Material List

The more random, unrelated supplies the better.

- Small flashlights
- Simple noisemakers such as bells, triangles, or whistles
- Cups and string
- Slinkys
- Legos
- Desk supplies or other random objects

Encourage students to test and iteratively improve their designs.

Teaching Tip

Introduce the concept and process of “iterative design” with groups as they reach what appears to them to be “the end.” Repeatedly coax them to make their design better and better.

4. Test the student message systems (20 min)

- Invite each group to demonstrate its solution to the class.

After each presentation, encourage the group to discuss improvements that they would like to make and challenges they encountered in creating their solution. Invite the students in the audience to ask questions, discuss the challenges the presenters reported, and share ideas they may have.

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5. Class discussion of project (10 min)

If it doesn't come out during the presentations or the follow-up discussions, guide the class to examine the limitations of the project.

- The communication challenges of being able to send only two possible messages.
- The need to agree ahead of time on what the signals mean.
- The lack of security—once the code is known it is easy for anyone to understand the message.
 - + Encourage students to think about security while working on their design. It is not a requirement at this time and will be discussed in depth later.

6. Journal Entry

Prompt students with: **“What binary messaging systems are currently used in this room or school? How effective are they?”** Possible answers include: smoke detector, metal detector, cell phone ringtones. It is possible to extend the conversation about ringtones to foreshadow the students' next challenge by discussing how a single ringtone has evolved into multiple ringtones that can signal various things. Similarly, vibrations can signal different things based on length or number.

ACTIVITY: SENDING MULTIPLE BITS —125 MIN**7. Sending more complex messages (90 min)****Curriculum Connection**

This activity supports the goals found in the Common Core State Standards for Mathematics: Understanding number systems.

- Present students with a revised problem statement: **“Create a system to send a more complex (text) message across a distance of at least 10 feet using the materials provided.”**

Students should have concluded that the binary messaging systems they created earlier were relatively simple and limited for practical use. The goal is now to challenge the students to design a system that will send more complex messages such as words. As before, keep the prompt direct and open-ended. Allow the students to struggle for a little while, but be ready to help if their frustration becomes too great.

Teaching Tip

To help frustrated students, reference their earlier work on encoding bits or review the ECS activities on binary encoding of text. Use your best judgement as to whether you need to present these ideas to the entire class or to individual groups as needed.

The important connection that students should make in this portion of the project is that the same binary messaging system designed earlier can be used to create a system to encode more complex messages.

This portion of the project is allotted the greatest amount of the student working time. Some students will likely finish much more quickly than others. It is important to continue to encourage these groups to think about how to improve their message transmission systems.

Extended Learning

This might be an appropriate time to introduce the concept of “metadata,” with or without using the actual term.

- As you move about the room, ask groups if they have thought about these common problems:
 - + How can you make the messages shorter?
 - + How can you transmit more quickly?
 - + How can you make the messages more secure?
 - + How can you ensure that the person receiving your message received the correct information?

8. Gallery walk to display student messaging systems (25 min)

- Instruct student groups to create video demonstrations of their messaging systems. The demonstration must show the messaging system transmitting a text message that is at least 5 characters long.

Curriculum Connection

Future performance tasks in this curriculum will require students to video record various aspects of their projects. This is an opportunity to test the video recording equipment in the classroom.

- Rotate students to view each messaging-system demonstration video. Instruct students to calculate the bitrate for each groups’ transmission system.

Did you know?

Bitrate is the speed at which data is transmitted. Students can calculate the bitrate of the student-created transmission systems by merely counting the number of bits sent per-second or per-minute.

- Class discussion. Prompt students with the following questions about the demonstrations and their experiences:
 - + What did you see that surprised you?
 - + What did you see that worked really well?
 - + What did you see that you could use to improve your project if you had more time to work on it?
 - + Which group demonstrated the fastest messaging system? How fast do you think computers can send bits?
 - + And, did your team have problems working together? How were they solved?
- Evaluate student projects with the rubric at the end of this lesson document.

Alternative Approach

If video equipment is not readily available, students can demonstrate their systems “live” for the entire class. Answer questions at the end of each demonstration.

ACTIVITY: EXPLORING REAL-WORLD DATA TRANSMISSION SYSTEMS — 75 MIN

This lesson is about understanding the physical layer of the Internet. Problems at the physical layer are concerned with how to transmit a bit from one place to another using some medium. In the real world of electricity, radio waves, light, and sound are common physical transmission media.

In this lesson, students used physical objects to transmit bits...the same problems they encountered using the makers supplies are the same problems of real world transmission systems.

9. Real-world data transmission system jigsaw: Research a transmission system and teach other classmates.

- Assign each group a transmission medium to research and report on how bits are transmitted using that medium.
 - Sound (dial-up modem)
 - Electricity (cable)
 - Radio waves (Wi-Fi, cell phone)
 - Light (fiber optics)

Students should record details about each transmission system to complete their “jigsaw puzzle” of knowledge. A chart for recording student learning may be helpful. Students should draw connections between the real-world and their student-created medium related to how the transmission works, typical bitrate, security issues, common applications, advantages, and disadvantages.

ASSESSMENT QUESTIONS

- Can you send a message in binary to someone you’ve never before communicated with? If yes, how? If no, what does the person receiving a message need to know in order to successfully decode the message?
- For the final project in this lesson, you created an encoding strategy or system to convert a text message to binary. Why did you choose that particular encoding strategy? List at least two reasons to justify your decision. List two issues or problems that could be improved in your encoding strategy.

Teaching Tip

If students are unable to answer these questions, ask “Could you send a message in another language using your encoding?”, “Are there any messages you cannot send?”, or “Can you send emoji using your encoding.” Advanced students should be pushed to explain why they add emoji packs to their cellphone messages before sending, or why emoji on Android phones looks different than on iPhones.

Did you know?

Emoji is the Japanese word for ideograms or smileys. Their popularity has spread because they are now incorporated into Unicode and available on many phones.

- The student-designed messaging systems created in this lesson will be assessed with a rubric aligned to the CSP Learning Objectives. The rubric is available at the end of this lesson and in the Teacher Resources Collection.

CONNECTIONS AND BACKGROUND INFORMATION

In the *CS Unplugged Secret Message* lesson, students learned to send messages with simple binary encodings and worked with a simple binary encoding of the alphabet (1=A...26=Z) . A review of of this content may be helpful before students start this Lesson 5.

The activities in Lesson 5 support *CSTA K-12 Computer Science Standards: 3B-7 Discuss the interpretation of binary sequences in a variety of forms.*

Project Rubric

Artifact: a data transmission system that sends a five character message.

CSP LEARNING OBJECTIVES	BEGINNING	EMERGING	PROFICIENT
Develop an abstraction.	Developed a system to represent two different states that can be transported a distance greater than 5 feet. However it is difficult for students in the group to identify the differences between states and decode messages.	Developed a system to clearly represent two different states that can be transported a distance greater than 5 feet. Students are able to identify the difference between the two states, but someone with no prior knowledge of the system would struggle to receive a message after the two states are explained to them.	Developed a system to clearly represent two different states that can be transported a distance greater than 5 feet. Students are able to identify the difference between the two states, and someone with no prior knowledge of the system can receive a message after the two states are explained to them.
Describe the combination of abstractions used to represent data.	Are unable to explain how the text message is converted to binary. Students with beginning knowledge are most likely unable to receive an unknown message over their system and successfully report its meaning.	Are able to articulate that the text message is (1) first converted into binary and then (2) converted into the two states represented in their transmission system.	Are able to articulate that the text message is (1) first converted into binary and then (2) converted into the two states represented in their transmission system. They can explain how any data that could be represented in binary could be transported over their system.
Analyze the considerations involved in the computational manipulation of information.	Cannot justify <i>why</i> they made choices about the order, start, or end of a message.	Can speak with detail about <i>why</i> they made specific choices about their medium, including, but not limited to, the order with which bits are sent, the start of a message, and the end of a message.	Can speak with detail about <i>why</i> they made specific choices about their medium, including, but not limited to, the order with which bits are sent, the start of a message, and the end of a message. Students can also discuss how their specific choices either do or do not address issues related to the speed of transmission, the length of messages, the security of messages, and the ease of interpretation of messages.
Collaborate in the creation of computational artifacts.	Do not respect and include the voices of all group members during creation or presentation of the project.	Respect and include the voices of all group members. All members are actively engaged at some point during the project and participate in the discussion of the project.	Respect and include the voices of all group members. All members are actively engaged throughout the project and participate in the discussion of the project.

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