Classroom Teacher Preparation

Technology 1: Binary Code, or How to Speak Computer

Please use the following to prepare for the next SfS lesson.

Description:

This introductory lesson provides a mathematical and conceptual basis for understanding how computers handle information. The first activity provides students with an opportunity to practice recognizing numbers written in the binary number base, which is the system that computers use to communicate with each other. In the second activity, students will both encode and decode English alphabetic characters to/from binary, illustrating how computers can be designed to communicate information to humans.

Lesson Objectives – SWBAT ("Students Will Be Able To…"):

4th-8th

- Demonstrate how to convert a base-10 number into a binary (base-2) number and vice versa
- Encode and decode text information into/from binary

Disciplinary Core Idea (DCI)

PS4 Waves and Their Applications in Technologies for Information Transfer - PS4.C Information technologies and instrumentation

- (3rd-5th) Patterns can encode, send, receive and decode information.
- (6th-8th) Waves can be used to transmit digital information. Digitized information is comprised of a pattern of 1s and 0s.

Science & Engineering Practice (SEP)

Using Mathematics and Computational Thinking

- (3rd-5th) Organize simple data sets to reveal patterns that suggest relationships.
- (6th-8th) Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.

Crosscutting Concept (CCC)

Patterns

- (3rd-5th) Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.
- (6th-8th) Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.

Preparation:

This lesson is intended to introduce binary numbers to students, so no special preparation is necessary. It is assumed, however, that students are familiar with the concept of place value in a base-ten counting system. (We do not recommend this for students in early 4th grade or 3rd grade until they have a better generalization understanding of the place value system).

Room Set Up for Activities:

A whiteboard (or appropriate substitute) will be helpful for the introduction. Students will work in pairs at their desks for the activity.

Safety:

There are no safety concerns with this lesson.

Related Modules:

This module can be related to lessons regarding **programming, technology,** and **procedural thinking**. Related modules from our lesson list include:

Scientific Practices 1: *Procedural Thinking* - Students work to create and follow clear ordered steps to replicate a classmate's creation from written directions.

Technology 3: Conditionals in Code – This foundational lesson introduces the concept of a conditional statement, relating it initially to students' everyday decision-making processes, and then using a game to allow students to observe the execution of conditional statements, as they would occur within the context of running a computer program.

Technology 4: Cryptography – A module full of fun activities introducing the basics of encryption, which has evolved into a critical element in modern data storage and Internet transactions.

Technology 6: Building a Webpage -- This module presents the basic structure of a web page. Student teams compete to "load" their webpage fastest, modeling the operation of a browser.

For other module sequences and groups, look here: www.sciencefromscientists.org/sequences

Standards Covered:

Please click the following link to our website to review the standards covered by this lesson, listed by state: www.sciencefromscientists.org/standards/

Lessons are matched to both national NGSS and local state standards.

After Our Visit:

Extend this lesson with our Binary Beading activity, where kids can encode a message into binary using two different colors of beads (includes options appropriate for both younger and older students). As a bonus, kids are exposed to the real ASCII table, and use standard 8-bit binary numbers.

Access this Extension activity by visiting the Classroom Post found on our website at sciencefromscientists.org/cohorts. Use the name of your school/cohort and password to log in.

To help Evaluate, check out our Open Response questions online at sciencefromscientists.org/open-response-questions. They are freely available for all of our lessons for current teachers. Use the password supplied by your instructor to log in.

Additional Resources:

- More extensive discussions of binary numbers:
  - https://circuitcrush.com/binary-numbers-basics/
  - https://www.mathsisfun.com/binary-number-system.html
- This link to the Schoolhouse Rock multiplication by 12 video does not directly relate to conversions into base 2, but it illustrates the way that a species develops a counting system: https://www.youtube.com/watch?v=_uJsoZheTR4
- Lots of different activities, using both the binary number system and its technologically-important relative, hexadecimal, are available here: https://classic.csunplugged.org/binary-numbers/

- History of the text-to-binary encoding schemes ASCII and Unicode:
  - https://www.eetimes.com/author.asp?section_id=216&doc_id=1285465
  - https://www.youtube.com/watch?v=MijmeoH9LT4
- Once students have appreciated the ways that Unicode improves on ASCII, they may be amused by the following: https://www.unicode.org/history/20thceleb/20thceleb.html