GYSTC
GEORGIA YOUTH SCIENCE & TECHNOLOGY CENTERS

Title: Binary Code STEM Challenge

Estimated Time: 1-2 periods

Note: This challenge doesn't fit a particular Georgia Science Core Standard very well. It does fit an ISTE Standard (below) as well as multiple Science and Engineering Practices and Crosscutting Concepts. Because Binary Code is the fundamental language used by computers and other digital devices, it is important that are students learn more about it. This lesson works best with 3rd-8th graders.

International Society for Technology in Education (ISTE) Standard 7: Global Collaborator

Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

7a Students use digital tools to connect with learners from a variety of backgrounds and cultures, engaging with them in ways that broaden mutual understanding and learning.

Science and Engineering Practices:	**Crosscutting Concepts:**
Developing and Using Models: Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. **Using Mathematics and Computational Thinking:** Organizing simple data sets to reveal patterns that suggest relationships.	**Systems and System Models:** A system is a group of related parts that make up a whole can carry out functions its individual parts cannot. **Structure and Function:** Substructures have shapes and parts that serve functions.

STEM Challenge Overview:

The initial task in this challenge is for students to use their understanding of binary code to construct a name bracelet. The final task in this challenge is for you to artistically represent the importance of binary code as the fundamental language of computers. You can do this by showing bytes of code in creative ways or you can represent an important thing, person or idea in binary code. If you want, you can also use things like candy, beans, buttons, coins or even small vegetables to represent the 0's and 1's of binary code.

Ask	Allow the students to **ask** questions about computer coding (programming). Have them read the ***Computer Coding is Cool*** article and discuss the importance of transistors, microchips, and binary code.
Imagine/Brainstorm	Discuss the structure of binary code noting that it takes into account the fact that computers can only produce two types of data: on and off. Highlight why we have assigned the symbol for "0" for off and "1" for on. It makes for a super simple computer code alphabet has only two letters – make that numbers. After creating their binary bracelets in Part 1, students **brainstorm** ideas that could be used to artistically represent the importance of binary code as the fundamental language of computers. They can do this by showing bytes of code in creative ways or they can represent an important thing, person or idea in binary code. If needed, show them some examples to get their creative juices flowing.

Plan/Design	Students **plan** an organized approach to represent the importance of binary code. This may include a rough **design** (sketch) of their ideas and/or a procedure for completing their creation.
Create/Test	Students follow their plan as they **create** an artistic representation of this cool code. Once it is created, students **compare** their piece to others in the class as a way to evaluate the quality of their representation.
Improve	After discussing and evaluating their results, students suggest way to **improve** their representation and tweak their design as time permits.

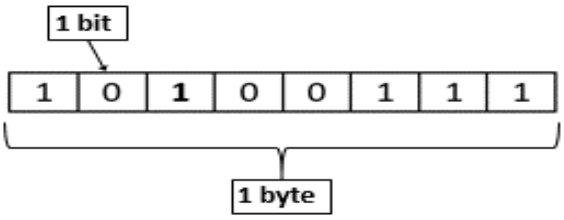
Teacher Notes:
This STEM Challenge provides an excellent introduction to binary code. Although students are now learning more and doing more with computer programming (coding), they often have little idea of how computers communicate. Before beginning this challenge, take time to discuss some key points with your students. It is recommended that you let them read the article ***Computer Coding is Cool*** before you discuss these points.
For older students, you might include some of the historical highlights surrounding digital development. It all started with computers over 50 years ago when scientists invented something called a vacuum tube. Unlike household vacuums that clean dust and dirt from your carpet, vacuum tubes helped electricity to flow through electrical circuits while turning on and off in meaningful patterns. Vacuum tubes made it possible to invent televisions and computers and other things that relied on these on-off patterns. The problem was they were big and expensive and they tended to overheat and burn out.

Fortunately, transistors were also invented not long after the vacuum tube. Like vacuum tubes, transistors help electricity to flow and turn on and off in patterns. But, unlike vacuum tubes, they are hundreds of times smaller so you can use them to make lots and lots of circuits that can be connected to one another, or integrated, in meaningful ways.

As transistors were being developed, so was something called a microchip. The microchip provided a place for all the electrical parts of a circuit to be located. Microchips were made on a very small (microscopic) scale so that one device such as a cell phone could contain millions of microchips - each of them accomplishing an important function. Most importantly, microchips could also store information in the form of computer memory.

The information in a microchip is stored in a kind of "alphabet" known as binary code. Binary code takes into account the fact that computers can only produce two types of data: on and off. As we learned earlier, these on-off patterns are produced by the transistors within each microchip. It is kind of weird to realize that the complex actions and functions of modern computers are the result of something so simple.

To make this even easier for humans to understand, we have assigned a symbol for "on" and a symbol for "off". While we could have chosen something like "A" for on and "B" for off, someone smartly decided to use numbers instead. Since zero already refers to nothing or zilch, it is the perfect fit to represent "off" for a computer. And since only one more symbol was needed, it only seems logical that 1 was the choice for "on". So our super simple computer code alphabet has only two letters – make that numbers.



One unit of this code, either a 0 or a 1, is sometimes known as a bit. Bits, as you might have guessed, are often placed into groups like the letters in a word. By grouping single bits together in larger and larger groups, computers can use binary code to find, organize, send, and store more and more kinds of information. The most common way they are grouped is into sets of eight with each set of eight is commonly known as a byte.

In this STEM Challenge, the initial task in this challenge is for students to use their understanding of binary code to construct a name bracelet. Using dark colored beads to represent 0's and light colored bead to represent 1's, they construct a bracelet to represent their first name, initials, or nickname. The final task in this challenge is for students to artistically represent the importance of binary code as the fundamental language of computers. They can do this by showing bytes of code in creative ways or they can represent an important thing, person or idea in binary code. Students can also use things like candy, beans, buttons, coins or even small vegetables to represent the 0's and 1's of the code. We want students to be aware that, while computers use a bunch of different codes like bar codes and QR codes, they are fundamentally programmed with binary code – patterns of on's and off's.

With respect to Science and Engineering Practices, students are developing and using models in this lesson as they construct the bracelet - an abstract representation of binary code. They are also using computational thinking as they organize bytes of code into meaningful patterns. In regards to crosscutting concepts, binary code acts as a system and group of related parts to provide a coherent language for computers.

Materials Needed (per person):
1 pipe cleaner (Chenille Stem)
15 dark beads, 15 light beads, 5-6 spacer beads (we buy beads in bulk from Amazon – you can get 1500 for about $5 at Walmart).
Beans, assorted small candies like M&M's or Skittles, coins, buttons, some small vegetables like cut up peas and carrots.

Print Out or create a Powerpoint Slide that can be used with students:

Binary Code Name Bracelets

Character	Binary Code	Character	Binary Code
A	01000001	a	01100001
B	01000010	b	01100010
C	01000011	c	01100011
D	01000100	d	01100100
E	01000101	e	01100101
F	01000110	f	01100110
G	01000111	g	01100111
H	01001000	h	01101000
I	01001001	i	01101001
J	01001010	j	01101010
K	01001011	k	01101011
L	01001100	l	01101100
M	01001101	m	01101101
N	01001110	n	01101110
O	01001111	o	01101111
P	01010000	p	01110000
Q	01010001	q	01110001
R	01010010	r	01110010
S	01010011	s	01110011
T	01010100	t	01110100
U	01010101	u	01110101
V	01010110	v	01110110
W	01010111	w	01110111
X	01011000	x	01111000
Y	01011001	y	01111001
Z	01011010	z	01111010

Can do:
1. First name to 4 letters
2. Initials
3. Nickname to 4 letters

Dark Color = 0
Light Color = 1
Third Color = Spacer

You need:
15 Dark Beads
15 Light Beads
5 Spacers
1 Spacer at start
1 Spacer in between
2 Spacers at end.

Because computers only understand patterns of 0's (off) and 1's (on).

Contributed by:
Dr. Tom Brown,
GYSTC Director of Statewide Programs
tbrown@kennesaw.edu

Binary Code STEM Challenge:

Part 1: Can you use your understanding of binary code to construct a name bracelet?

Part 2: Can you to artistically represent the importance of binary code as the fundamental language of computers?

or

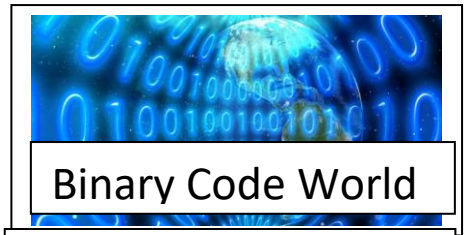
Can you artistically represent an important thing, person or idea in binary code?

Part 1: Constructing your Name Bracelet:

1. You can do:
    - First name up to 4 letters
    - Initials
    - Nickname up to 4 letters
2. Choose a dark color for 0's and a light color for 1's. Count out 15 of each.
3. Choose another color for spacers. Count out 5.
4. Use the Binary Code alphabet to determine the sequence of 0's and 1's for each letter.
5. Include 1 spacer at the start, 1 between letters, and 2 at the end.
6. Construct your bracelet one bead at a time.
7. After completing the bracelet, "read" the bracelet to your partner.

Part 2: Symbolizing the Importance of Binary Code:

1. The final task in this challenge is for you to artistically represent the importance of binary code as the fundamental language of computers.
2. You can do this by showing bytes of code in creative ways or you can represent an important thing, person or idea in binary code.
3. If you want, you can also use things like candy, beans, buttons, coins or even small vegetables to represent the 0's and 1's of binary code.



Binary Code World

Binary Code Paper

Evaluating and Improving:

1. As a group, discuss how you were able to artistically represent the importance of binary code as the fundamental language of computers. Explain the symbolism that you used to show the qualities and/or ideas that are part of binary code.
2. Compare and contrast your symbolic creation with those of other groups in your class. Describe the qualities of your favorite symbolic representation. If you were doing this again, what could you add to your design that could improve the quality of your work?
3. Finally, describe how binary code acts as a system and group of related parts to provide a coherent language for computers.