Lesson Extension: Patterns in Nature

Detecting Patterns
What does it take to crack a secret code? The answer is no mystery – you must recognize a pattern and then reverse it. In this lesson, students will code and decode secret messages using their mathematical and logical reasoning skills. Students will have fun discovering that all codes—and all patterns—are governed by predictable rules. Indeed, even patterns in nature, like a tree’s branching pattern, the venation in a leaf, or the arrangement of stamens in a flower, can be observed, measured, and categorized.

Objectives
• Create and solve simple coded messages.
• Understand that all codes consist of patterns that follow predictable rules.

Materials
• Pencil
• Paper

Activity
• Begin by introducing students to the Caesar Cipher, a simple substitution code. Named after Julius Caesar, who supposedly used it to encrypt military messages, it involves replacing each letter in a message with a different letter that is a fixed number of positions down the alphabet. For instance, in a shift of two, A would become C, and B would become D.
  ◊ Write the alphabet on the board, as well as a message encoded with the cipher. An example using a shift of 2 would be

  A Q W C T G C P C O C B K P I E N C U U!
  Y O U A R E A N A M A Z I N G C L A S S!

  ◊ Ask students to brainstorm ways they could solve the cipher. One easy way to solve a Caesar Cipher is to shift the letters of the message backwards by one, two or three, and so on, until recognizable words appear. In this case, a shift of one would begin to spell Z P V, which students would quickly realize was not the answer.


  ◊ But a shift of two does spell a recognizable word, You, which cracks the code. Students could also try substituting the most frequently used letters in the alphabet for the most frequently used letters in the code.
• Next, introduce students to a more complex variation of a substitution code. This, time they will add, subtract, multiply or divide their key by a secret number. First, students should convert each letter of their key to a number, with A as 1 and Z as 26. For example, Happy Friday would become:

  H A P P Y F R I D A Y
  8 1 16 16 25

With an encryption that adds two to each number, the new code is:

10  3  18  18  27  8  20  11  6  3  27

- Once the students have solved the codes, challenge them to try creating their own code for a classmate to solve.
- Invite students to share out their invented codes.

**Discussion Questions**

- Which codes do you think would be the easiest to crack? Which would be the hardest? Why?
- How do we use encryption or codes in modern life? Some possible examples for discussion include: Braille, hidden computer viruses, compressed mp3 files, DNA sequencing and texting.
- Given what you now know about solving codes, why do you think certain computer passwords are safer than others?
- What patterns did you notice when you were coding or decoding messages?

**Additional Codes**

- **Transposition** is a change in order or position. A transposition cipher involves keeping the same letters as in the original message, but rearranging them. For example, when reversing every other letter “Happy Birthday” becomes “ah pp by ri ht ad y.”

- A **polyalphabetic cipher** uses multiple substitution alphabets. Different symbols can stand for the same letter and the same symbol can stand for different letters. A polyalphabetic cipher does not use one-to-one substitution of letters, so cracking a code by checking for letter frequency becomes more difficult. These ciphers can be solved by using a table or a secret key.

- A **Date Shift Cipher** is a polyalphabetic cipher that uses a date as a key. The letters of a date are written under each letter of a message and repeated as needed. If the message were Happy Independence Day and the key were the date 7-4-1776, you would write:

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H A P P Y   I N D E P E N D E N C E   D A Y
7 4 1 7 7  6 7 4 1 7 7  6 7 4 1 7 7  6 7 4
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Then, each letter is shifted forward by as many spaces as the number written beneath it. Our example above would become:

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O E Q W F   O U H F W L T K I O J L   J H C
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When a code is sent, the recipient, having been given the date that is the key, writes the date beneath each letter and then counts backward to the correct letter based on the number beneath each letter.
Common Core State Standards

CCSS.MATH.CONTENT.4.OA.C.5
Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.

Next Generation Science Standards

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

Resources

https://www.nsa.gov/kids/home.shtml