



LESSON PLAN: Spying with Math

Elementary School (4-5)

OVERVIEW

By studying the basics of cryptology (the science of breaking codes), students will use a few of the necessary STEM skills required to complete this type of work, including graphing skills, pattern recognition, and classification techniques.

Students will first explore the structure and history behind codes. By analyzing the one-to-one cipher, students will experience the thrill of code breaking with the guidance of their teachers. Afterwards, students will complete three stations reviewing necessary math skills: graphing, pattern recognition, and classification.

This lesson is recommended for the end of the year as a review of various math skills.

Estimated time: One class period (50-70 min)

STANDARDS

Content standards vary by state. This lesson can be used to teach the following state standards and similar wording may be found in your state standards.

- CCSS.MATH.CONTENT.5.G.A.1: Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arrange to coincide with the 0 on each line and a give point in the plane located by using an ordered pair of numbers, called its coordinates.
- CCSS.MATH.CONTENT.5.G.B.3: Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category.
- CCSS.MATH.CONTENT.5.OA.B.3: Generate two numerical patterns using two given rules.
- CCSS.MATH.CONTENT.5.NF.B.4: Apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction.
- CCSS.MATH.CONTENT.5.NF.B.7: Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions.

LEARNING OBJECTIVES

- Students will recognize patterns in two different number sets
- Students will graph various data points
- Students will classify different shapes into their respective categories



- Students will multiply and divide fractions
- Students will practice the foundations of a one-to-one cipher

RESOURCES NEEDED


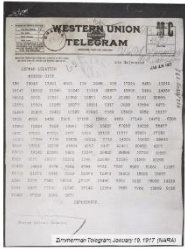
- “Spying with Math” PowerPoint (optional)
- Fractions Worksheet and Teacher Key
- Pattern Worksheet and Teacher Key
- Triangle Worksheet and Teacher Key
- Graphing Worksheet and Teacher Key

LESSON ACTIVITIES



CRYPTOLOGY LESSON:

The teacher will guide students through a PowerPoint that explores the history of cryptology and the basics of codes and ciphers. This short lesson will introduce students to one-to-one substitution ciphers and frequency tables, and will guide students as a class through a few different example codes and concepts. (This part of the lesson is optional.)

Time: 20 minutes

Slide:	Script:
 <p>Spying with Math An Introduction to Cryptology</p>	<p>Today we’re going to become secret agents and solve codes using math.</p>
<p>What is Cryptology?</p> <ul style="list-style-type: none"> • Method used to hide a message • Making and breaking codes • Code: Letters or words used for other letters or words. • Cipher: Key used to decode a message. 	<p>Cryptography or cryptology is a method used to hide the meaning of a message. When a person wants their message to be secret, they create a code to protect that message. A code is the secret message where the actual letters and words are replaced with other words, letters, or symbols. The cipher is then used to help break the code. A cipher is the key that takes the code and reveals its true meaning.</p>



<p>When was Cryptology Created?</p> <p>Ancient Egypt: Hieroglyphics</p>  <p>Rome: Caesar Shift Cipher</p> 	<p>The first use of cryptology was in ancient Egypt. As early as 1900 BCE, Egyptians used hieroglyphics to hide messages. The Romans also used cryptology and developed a method that is now called the Caesar Shift Cipher, in which they would shift the alphabet a certain number of spaces to create a new code. For example, if we shifted two spaces, "A" would now be "C" in the code.</p>
<p>Where Do We Use Codes?</p> <p>How do you use codes every day?</p> 	<p>You may be surprised to learn that we all use codes every day. Let's try to brainstorm a few ways we or the people around us use codes.</p> <p>Think of examples of when you might use a symbol or a small action to mean something else. For example, what is this *nod head* a code for? It's a code for yes, correct!</p> <p>Can anyone think of anything else? (Come up with a class list or move on to the next slide.)</p>
<p>Examples of Codes</p> <ul style="list-style-type: none"> Baseball Teacher signals Traffic lights 	<p>Good job! Here are some more examples.</p> <p>In baseball, coaches use hand signals to tell batters when they are going to bunt or steal a base. How many of you have played baseball or softball and seen these signals?</p> <p>What do we do when we need to use the restroom? What does that signal mean? What other "codes" or signals do we use in our classroom?</p> <p>When we see green on a traffic light, what does that mean? The green is a code that tells drivers they can go forward.</p>



<p>One-to-One Codes</p> <p>One letter or symbol represents another</p> <p>Let's practice!</p> <p>Solve the code:</p> <p>T FN RNFMWI</p> <p>Why this works: There are 403,291,461,162,605,635,584,000 possible alphabets</p> <table border="1"> <tr> <td>A = F</td> <td>B = K</td> <td>C = P</td> <td>D = U</td> <td>E = Z</td> </tr> <tr> <td>F = E</td> <td>G = J</td> <td>H = O</td> <td>I = T</td> <td>J = Y</td> </tr> <tr> <td>K = D</td> <td>L = I</td> <td>M = N</td> <td>N = S</td> <td>O = X</td> </tr> <tr> <td>P = C</td> <td>Q = H</td> <td>R = M</td> <td>S = R</td> <td>T = W</td> </tr> <tr> <td>U = B</td> <td>V = G</td> <td>W = L</td> <td>X = Q</td> <td>Y = V</td> </tr> <tr> <td>Z = A</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	A = F	B = K	C = P	D = U	E = Z	F = E	G = J	H = O	I = T	J = Y	K = D	L = I	M = N	N = S	O = X	P = C	Q = H	R = M	S = R	T = W	U = B	V = G	W = L	X = Q	Y = V	Z = A					<p>There are many types of codes. This type of code is called a one-to-one code. This type of code has one letter or symbol that represents a different letter or number.</p> <p>Let's practice. In the table, the letter that is bold is the original letter; the not bold letter is what is in the coded message. Using our detective skills, let's solve this code.</p> <p>Answer: I am smart</p> <p>Let's use the same table to create a coded message of our school name. (Do together on board or paper)</p> <p>This type of code has 403 septillion possibilities!</p>
A = F	B = K	C = P	D = U	E = Z																											
F = E	G = J	H = O	I = T	J = Y																											
K = D	L = I	M = N	N = S	O = X																											
P = C	Q = H	R = M	S = R	T = W																											
U = B	V = G	W = L	X = Q	Y = V																											
Z = A																															
<p>Using Math to Solve Code: Frequency</p> <ul style="list-style-type: none"> - Frequency: How often a letter is used - What is the most commonly used letter in our alphabet? - What do you think the most common 3 letter word is? <p style="text-align: center;">_____</p> <p style="text-align: center; font-size: 2em;">?</p>	<p>When we solve codes using frequency, we must look for how often a certain letter or symbol appears and determine the letter that it most likely represents.</p> <p>To do that, we need to know the most common letter used in English. What letter do you think that is?</p> <p>The most common letter is "e."</p> <p>If "e" is the most common letter, what do you think the most common three-letter word is?</p> <p>The most common three letter-word is "the."</p> <p>So when cryptologists look at a code, they will find the most used letter or symbol and see if it matches with the letter "e," as well as three-letter words to see if they corresponds with the word "the."</p>																														



Practicing Frequency	
<p>Let's practice!</p> <p>Code:</p> <p style="text-align: center;"><u>PRH PWHH CN LWHHQ.</u></p> <p>What letter is the most frequent?</p> <ul style="list-style-type: none"> · What letter do you think that letter represents? · What can we infer about what word "PRH" stands for? · What word could "PWHH" be? 	<p>Now, let's use what we just learned to try to solve this code without having a key.</p> <p>The most frequently used letter in this code is "H." Based off of what we know about frequency, that means "H" probably represents the letter "E" in this code.</p> <p>Given that "H" is "E", we know that PRH is a three-letter word ending in "E". What word might that be? "The" is correct!</p> <p>Now what do we know? We know that P=E, R=H, AND H=E. Given this information, what does the code now say? THE T_EE ____EE_.</p> <p>What word could the second word be? Brainstorm words together. The second word is "tree"!</p> <p>Now we know "W" stands for "R", which means the last word is _REE_.</p> <p>ANSWER: THE TREE IS GREEN.</p>

MATH STATIONS:

After completing the optional cryptology lesson, students will complete four different stations to practice math skills within secret agent scenarios.

Time: 1 hour

- **Station 1: Solving Equations (15 min)**
 - The worksheet has four tables and a rule. The students compare the two sets of numbers and, using the rule, complete the missing spaces on the table. For the final table, students must compare number sets and list the rule.
 - Resources needed:
 - Pattern Worksheet
 - Pattern Teacher Key
- **Station 2: Graphing (15 min)**



- Students will use the graphing instruction paper to map points on their corresponding empty graph plot. There are two parts of the object, which when completed should reveal a secret tool used for spy work.
- Resources needed:
 - Graphing Student Instructions
 - Graphing Empty Plot
 - Graphing Teacher Key
- **Station 3: Classification (15 min)**
 - Students will classify types of triangles to crack a locked safe.
 - Resources needed:
 - Triangle Classification Worksheet
 - Triangle Classification Teacher Key
- **Station 4: Fractions (15 min)**
 - Students will solve fraction equations to determine a letter, which will allow them to decrypt a one-to-one substitution code.
 - Resources needed:
 - Fractions Worksheet
 - Fractions Teacher Key

LESSON EXTENSIONS:

- Visit Arlington National Cemetery to learn more about military intelligence:
<https://education.arlingtoncemetery.mil/Themes/Military-Intelligence>.
 - School Military Intelligence Walking Tour
 - Children’s Military Intelligence Activity Packet
- Schedule a field trip to the National Cryptologic Museum:
<https://www.nsa.gov/History/National-Cryptologic-Museum/Museum-Tours/>.

PHOTOS:

- <https://kids.nationalgeographic.com/history/article/the-women-codebreakers-of-world-war-ii>
- <https://catalog.archives.gov/id/302025>
- <https://www.loc.gov/pictures/resource/ppmsca.05042/>
- https://commons.wikimedia.org/wiki/File:Caesar_cipher_left_shift_of_3.svg
- <https://www.flickr.com/photos/usnationalarchives/3678687013/>
- <https://catalog.archives.gov/id/556303>