

Exploring Encryption and Design Solutions

Companion Lesson to X-STEM All Access Episode “[One-on-One With a Space Force Guardian](#)”

Grade/ Grade Band: 6-12	Topic: Cyber Security	
<p>Brief Lesson Description: After viewing the X-STEM episode with Space Force Guardian Chief Abifarin Scott, students study the basics of encryption to get a sense of the operation Chief Scott oversees, the work the satellites do, and how it all keeps them and the country safe. Students will learn the fundamentals of encryption, model encryption and decryption, and discuss solutions to enhance security.</p>		
<p>Performance Expectation(s): NGSS MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. NGSS MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. NGSS HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p>		
<p>Specific Learning Outcomes: Students will be able to:</p> <ol style="list-style-type: none"> 1. Explain why encryption is an important tool for everyday life on the Internet 2. Use a model (Caesar Cipher and Random Substitution Cipher) to encrypt and decipher messages 3. Explain the weaknesses and limitations of the model and discuss possible solutions to changing the model 		
<p>Narrative / Background Information</p>		
<p>Prior Student Knowledge: It is not necessary, but prior to the lesson if students are able to describe, identify, and use algorithms it would make discussions more engaging.</p>		
<p>Science & Engineering Practices: Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</p> <ul style="list-style-type: none"> • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) 	<p>Disciplinary Core Ideas: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> • The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) 	<p>Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> • The uses of technologies and limitations on their use are driven by individuals, or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)
<p>Possible Preconceptions/Misconceptions: Students believe that complex passcodes can’t be hacked. However, with special programs even the longest password can be cracked.</p>		
<p>LESSON PLAN – 5-E Model</p>		

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions: Prior to the lesson gather the following items:

- scissors (one per team of students)
- brads (one per team of students)
- [Caesar Wheel Handout](#) (one per team of students)
- laptops with internet access

1. Write this secret message on the board. Secret Message: **serr cvmmn va gur pnsrgrevn**
2. Give students 3 minutes to attempt to decode the message.
3. Let students know this message was encrypted using a Caesar Cipher (an “alphabetic shift”). Tell students the Caesar Cipher technique is one of the earliest and simplest methods of encryption technique. It's simply a type of substitution cipher, i.e., each letter of a given text is replaced by a letter some fixed number of positions down the alphabet. For example, with a shift of 1, A would be replaced by B, B would become C, and so on. The method is named after Julius Caesar, who supposedly used it to communicate with his officials.
4. Group students into teams and give each team of students the [Caesar Wheel handout](#) to create their own decoder. (7 mins)
5. Allow students at least 5 more mins to decode the message without a hint.
Answer: free pizza in the cafeteria (hint: alphabet is shifted 13 characters)
6. Lead the follow-up discussion comparing how long it took to decipher the message independently and without an encryption technique versus using the Caesar Wheel tool to decode the message. Try asking the following questions to prompt the discussion: Did you find the decoding tool useful? Did you find working with others helpful? What was your strategy for using the Caesar Cipher? What if the message was a paragraph-long, do you think this particular cipher would be useful?

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Requires computers with internet access.

1. In pairs, students will use laptops with internet access to decipher a couple of encrypted messages using the [Encryption Widgets on Code.org](#)
2. Ask students define the following terms based on the 2 activities they just completed: cipher, encryption, decryption
3. Conduct a think, pair, share: asking students why encryption would be relevant to their daily lives? When do they need to send a secret message? (Possible ans.: sending messages to friends, online shopping, submitting an assignment online)

EXPLAIN: Concepts Explained and Vocabulary Defined:

1. Tell students, “Instagram, CashApp, and WhatsAPP all use encryption to share messages”. “What do we mean by encryption?”
2. Define encryption based on the responses students share to say: encryption is a process for coding messages to keep them hidden from unauthorized parties.
3. Ask students why they think these apps use encryption. (Possible ans.: makes sure the message gets to the intended person; no one can steal their money/data; only the person with permission has access)
4. Then ask students by a show of hands if they use Tik Tok. Let students know that messages on Tik Tok are not encrypted.
5. Using a turn and talk, have students grapple with the question, “how might unencrypted messages impact the Tik Tok user”.
6. Explain that the app collects not only meta-information but also the content of the messages sent through the app and can be read by the service provider and by third parties; your personal data can be shared with anyone. Hence you can get ad messages about the new sneakers you just texted to a friend.
7. Then ask students to imagine if the U.S. satellites were not encrypted what could be some consequences.
8. Tell students this is one of the roles of the U.S. Space Force, ensuring our security and prosperity as it relates to space systems involving satellites- from GPS Technology, to surfing the web, to calling our friends, to enabling first responders to communicate with each other in times of crisis. If students have not watched [One-on-One with Space Force Guardian Chief Abifarin Scott](#), now would be the ideal time to watch. If students have watched the video move on to the elaboration activity.

Vocabulary:

cipher- the term for a technique (or algorithm) that performs encryption

encryption- a process of encoding messages to keep them secret, so only “authorized” parties can read it

decryption- a process that reverses encryption, taking a secret message and reproducing the original plain text

algorithm- a set of rules for problem-solving operations/calculations

ELABORATE: Applications and Extensions:

Requires access to computers with internet.

1. Students return to the [Encryption Widgets on Code.org](#) to complete Lesson 8: Crack a Random Substitution Cipher.

- Students will explore a new cipher for 10 mins max. to discover how this new tool works to create and break the encoded messages. Ask students to make observations connecting this design to that of the Caesar Cipher and the first widget they used, noting similarities and differences and the reason/benefits of this new tool.
- Discuss with students how computers can decode and encrypt larger amounts of information more quickly now than in the past, which is why there is a need for a branch of the military to focus on encryption.

EVALUATE:

Formative Monitoring (Questioning / Discussion):

Affinity Mapping: ask students to record their thoughts on the question(s): **why should people be worried about information security?** or **why is cybersecurity necessary?** or **does keeping secrets make for more secrets?** (One idea per Post-It) and post them on the board. Students will then group the answers into similar categories, label the categories and discuss why the ideas recorded on the post-it notes fit into a particular category/how the ideas are related.

You are assessing students' understanding of how and why encryption plays a role in all our lives every day on the Internet, and making good encryption is not trivial.

Summative Assessment (Quiz / Project / Report):

Mini- Quiz: Caesar Cipher

The Caesar Cipher technique is one of the earliest and simplest methods of encryption techniques. It's simply a type of substitution cipher, i.e., each letter of a given text is replaced by a letter some fixed number of positions down the alphabet. For example, with a shift of 1, A would be replaced by B, B would become C, and so on. The method is apparently named after Julius Caesar, who apparently used it to communicate with his officials.

Question 1 Write a Caesar cipher algorithm in such a way that a character D is changed to N. Derive the encryption of the other characters accordingly. (ans.: Letter +16=D or N+16=D)

Question 2 Based on your algorithm, what will be the encrypted code of the message "my mother is not home". (ans.: co cejxuh yi dej xecu)

Elaborate Further / Reflect: Enrichment: Research other types of ciphers.

SOCIAL EMOTIONAL LEARNING ACTIVITY

SELF-AWARENESS and RELATIONSHIP SKILLS

In the X-STEM episode: [One-on-One with Space Force Guardian Chief Abiarin Scott](#), Chief Scott discusses how mentors inspired and advised him when he was struggling (starting at 6:57). Mentors can help one to hone their passion; mentors are trusted advisors who can provide academic, social, and career guidance. Use this activity to help students find a mentor.

Steps for Finding Your Next Mentor

Step 1: Define Your Goals and Challenges-ask students to write down the answer to "What personal or academic challenges do you face?" and to set a goal for what their life would be like if they overcame the challenge(s). The goal can be related to school, friendships, interests, or career. It's okay if they don't have a goal or are feeling lost, they can turn that into a goal of self-discovery. Note: this is not a SMART goal.

Step 2: Finding a Mentor Who You Know-have students create a list of adults who they know, like, and admire. Suggest students consider teachers, counselors, tutors, pastors, neighbors, and local shop owners. Their list should include what they admire about the individual and how the person would be able to support the student to achieve their goal(s).

Step 3: Asking for What You Want-students prepare talking points for the initial conversation with the person(s) they want as their mentor. Have students write out:

- an explanation why they believe a mentor would benefit them
- why they believe this person is best at fulfilling the roll
- include a description of current goals and challenges
- and then the big ask: if the person would be willing to meet (*x amount of time*) to discuss, encourage, and support you to achieve the goal(s).

Explain to students that a "no" is not the end, they simply repeat the process with someone else from their list.

Step 4: Building a Positive Relationship-explain to students that their mentor will learn as much from them as they do from the mentor.

Encourage students to be open, honest, and respectful. Let students know they should be asking questions, learning how the mentor thinks, and what their mentor values as they exchange perspectives without judgment.

The key objective here is to help students achieve more mature relationships with adults and emotional independence from parents and other adults (while maintaining these relationships).

INTERDISCIPLINARY CONNECTIONS/IDEAS

Language Arts: Working with the English teacher, when students read Julius Caesar discuss the ways in which encrypted messages might have been used (i.e. Cassius's notes to Brutus, amongst the conspirators, on the battlefields)

History/Social Studies: Chief Scott works to help keep the country safe, overseeing operations for collecting, producing, and integrating Department of Defense and Intelligence Community plans and strategies. During WWII, the US Military enlisted the Navajo Tribe members to help transmit coded messages in their native languages. Have students research the Indigenous People's role in the military including the Navajo Code Talkers.

Materials Required for This Lesson/Activity	
Quantity	Description
per team	scissors
per team	paper fasteners / brads
1-2 stack(s) per class	Post-it notes



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