Encryption – All About Code

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Students learn how alphanumeric symbols can be encoded for a multitude of fun purposes. In the first of two sessions (each 2 hours long) they learn about codes, and are asked to make their own with a limited number of symbols. In the second session they are asked to break each other's codes and discover the relationship among encryption, decryption, and shared keys.

Age Levels

Recommended for 8 – 10

Objectives

Introduce students to:

- Simple codes, including binary and Unicode/ASCII.
- How simple symmetric encryption/decryption works.
- How any symmetric code can be broken.
- Encryption schemes such as Cipher Wheels the Enigma Machine.
- That any code can be broken with good information and a lot of time.

Anticipated Learner Outcomes

Students will be able to describe:

- Some of the history of encryption.
- How encryption helps protect information.
- The relationship between encryption and decryption.
- How security is a constant game of cracking the code.

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

Binary Numbers (show one)

- https://www.youtube.com/watch?v=LpuPe81bc2w
- https://www.youtube.com/watch?v=TD6lcIIOeic
- https://www.youtube.com/watch?v=kcTwu6TFZ08
- https://www.youtube.com/watch?v=NK5Z6Oj0YkM Symmetric Key Encryption
- https://www.youtube.com/watch?v=jpiPc_o_J9c Jefferson Cipher Wheel first 1.5 minutes
- https://www.youtube.com/watch?v=elYw4Ve4F-I Enigma
- https://www.youtube.com/watch?v=3QnD2c4Xovk Public/Private Encryption (paint demo only)

Recommended Reading

- https://en.wikipedia.org/wiki/Encryption
- https://en.wikipedia.org/wiki/Cryptography

- Beissinger, Janet, *The Cryptoclub: Using Mathematics to Make and Break Secret Codes,* A K Peters/CRC Press, 2006 ISBN-10: 156881223X
- https://www.monticello.org/site/research-and-collections/wheel-cipher

Optional Writing Activity

- Can there ever be a code that can't be cracked? Pick a side of this debate and make a case for your perspective.

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For Teachers:

◆ Lesson Objectives

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◆ Materials

- Access to the Internet to watch the videos listed under Internet Connections.
- The student resource pages shown below.
- A pair of dice to create random numbers.
- Scissors, enough to easily share.
- Clear tape.

◆ Procedure

This lesson explores both simple and more complex cipher systems. It also introduces binary numbers as a code. Because the experience is for elementary students with a potentially wide range of arithmetic expertise, the activities are kept very simple and hands on. Session 1 explores simple codes, using binary numbers as an initial example. Cipher Wheels and Enigma are then introduced, and students are given the challenge of creating a code, and instructions for deciphering it.

Please be prepared to demonstrate the following in Session 1:

- The simplest kind of code involves shifting the letters a specified amount to the left or right. The key, in this instance is not the strip, but number of letter and whether it is a left or a right shift. Demonstrate this with a cipher strip from the Student Resource page.
- Students may decide to create a cipher wheel. They can attach the two ends of a cipher strip to create a physical wheel. By using multiple strips they can shift the letters in more complex ways. Have an example handy to demonstrate.

Session 2 allows students to try to break each others' codes, and wraps up with a video that opens the door to more complicated encryption techniques.

Session 1:

1. Show the binary number video most appropriate for your class. At most, spend 10 minutes discussing how binary numbers work.
2. Distribute Worksheet 1, and have pairs of students complete the worksheet.
3. Show the Jefferson Cipher Wheel and Enigma videos and discuss how the wheels can be viewed as strips of paper that are looped. Using your prepared samples, demonstrate how place shifting and wheels work.
4. As a group, brainstorm some ways to use the cipher strips, and take the opportunity to encourage imaginative solutions.

5. Distribute Worksheet 2, and help pairs of students create interesting codes. Make sure they write down their key. Remind them to write their name on each worksheet. As pairs complete this task, assign them another pair of students to swap messages. Collect everyone's Worksheet 2 to refer to in Session 2.

Session 2:

1. Distribute students' Worksheet 2. Have them create another coded message. This time have them hand off the message to someone without the key, challenging them to break each other's codes. Give help as needed, and as students break codes, have them help others as well. Consider offering a prize to the students who break the most codes, and whose codes weren't broken. Allow students whose code was broken to create another one. Limit this activity to approximately an hour.
2. Gather your students together for a discussion. On a white or black board create a list of all the different keys and whether they could be broken or not. Ask students to reflect on what it was about the keys that made them easy or hard.
3. Watch the public/private encryption video. Discuss why this extra layer is necessary for security. Challenge your students to poke holes in the algorithm: how could things go wrong.

◆ Time Needed

- ✦ 2 sessions, at most 1 hour each. This can be done in a single two-hour session if your students are typically cooperative during group activities.

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Student Resource: CIPHER STRIPS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

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Student Worksheet 1:
Binary Code.

Although it is not very secret, binary numbers are a code. (Why do you think they call it 'coding'?). To give you practice encoding and decoding a message, use this Unicode chart for the upper case letters as a cipher strip. For example, the word "HELLO" can be coded as:

1001000100010110011001001100100111 1

Decoding: Each letter above uses seven digits. Circle the digits for each letter, look up the number in the chart, and write the letter beneath the number.

Encoding:
Write a word here that is at least 5 and no more than 8 characters

_____ _____ _____ _____ _____ _____ _____ _____

Using the table, write out the word **on a separate piece of paper.** Have your partner check that you correctly encoded your work.

Give your paper to another member of your class. Challenge them to decode it.

A	1000001
B	1000010
C	1000011
D	1000100
E	1000101
F	1000110
G	1000111
H	1001000
I	1001001
J	1001010
K	1001011
L	1001100
M	1001101
N	1001110
O	1001111
P	1010000
Q	1010001
R	1010010
S	1010011
T	1010100
U	1010101
V	1010110
W	1010111
X	1011000
Y	1011001
Z	1011010

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Student Worksheet 2: Create Your Own Cipher

With a partner, invent your own cipher for the upper case letters in the English Alphabet. Be creative!

In Session 2 others will try to break your code. You can rotate to the left or right, make a cipher wheel, invent your on symbols, or let your imagination fly.

Write down your key here. Your key may be instructions for moving left or right on a cipher strip or it may be a cipher strip itself, or a number of cipher strips.

Key to encode	Key to decode

Testing your keys: (on a separate piece of paper)

Encode a short sentence based on the encoding rules.

Decode the sentence based on the decoding rules.

If you weren't able to correctly decode your sentence, study your keys and figure out how to fix them.

When your keys work, encode a question, and give it to another pair of students in your class with your keys. Have them decode the message and answer the message using your code.

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For Teachers:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Computer Science Teachers Association K-12 Computer Science Standards, and if applicable also the U.S. Common Core State Standards for Mathematics, the U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics, the International Technology Education Association's Standards for Technological Literacy, the U.S. National Science Education Standards and the U.S. Next Generation Science Standards.

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Understanding about science and technology

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Understandings about science and technology

◆Next Generation Science Standards & Practices Grades 3-5 (ages 8-11)

Practice 2: Generating and Using Models

- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

◆ Principles and Standards for School Mathematics (ages 10 - 14)

Problem Solving

- Solve problems that arise in mathematics and in other contexts

Connections

- Recognize and apply mathematics in contexts outside of mathematics

◆Common Core State Practices & Standards for School Mathematics (all ages)

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP4 Model with mathematics.

◆ Standards for Technological Literacy - all ages

Nature of Technology

- Standard 2: Students will develop an understanding of the core concepts of technology

The Designed World

- Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies

◆CSTA K-12 Computer Science Standards Grades 3-6 (ages 8-11)

5.1 Level 1: Computer Science and Me (L1)

- Computational Thinking (CT)
  3. Demonstrate how a string of bits can be used to represent alphanumeric information.

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For Teachers:
Alignment to Curriculum Frameworks

- Collaboration (CL)
  4. Identify ways that teamwork and collaboration can support problem solving and innovation.
- Community, Global, and Ethical Impacts (CI)
  4. Understand ethical issues that relate to computers and networks (e.g., equity of access, security, privacy, copyright, and intellectual property).