SECRET COMMUNICATIONS

Unit 1: Guess and Check: A Decoding Strategy

NOTES

Unit Objectives

Upon completion of this unit, students will:

- **Learn the frequency of letters used in the English alphabet**
- **Use frequency analysis to help decode monoalphabetic substitution ciphers**
- **Gain insights into decryption strategies**

Background Information:

Frequency analysis is a strategy of studying the frequency of letters that occur in encrypted messages. In English, certain letters are more commonly used than others. Knowing these letter frequencies helps to be able to take educated guesses when deciphering a substitution coded message. A substitution cipher involves replacing each letter of the original message with a different letter of the alphabet.

Counting the number of letters used in an encrypted message and matching them to letters that are known to be frequently used in English messages can provide a bit of information. This strategy will not always match up the most frequently used letters in a coded message with the most frequently used letters in the English language but with some persistence such information coupled with other observations may prove useful in the decoding of the encrypted message.

Inquiry Overview:

In this lesson students will apply careful observation skills along with frequency analysis strategies to gather information about encrypted messages. Students will be provided a coded message that will give them the opportunity to identify recurrent patterns. After identifying recurrent patterns in the message they will be introduced to data that describes the frequency that letters are used in the English language. Once the students become familiar with these strategies they will be offered the opportunity to use them to encode short messages for each other to decode.

NOTES

Activity One: *Message A* (45 – 60 minutes)

Objectives and Standards: SL.6-8.1; MP1; 6.RP.A.3; 7.SP.A.1

The students will:

- **learn the frequency of letters used in the English alphabet**
- **use frequency analysis to help decode monoalphabetic substitution ciphers**
- **gain insights into decryption strategies**

Suggested Inquiry Approach:

Set the stage for the activity by describing how messages can be coded by substituting one letter of the alphabet for another letter. For example, "A" might be represented by "G" with other letter substitutions in the original message following a rule for their conversion. After this short presentation give each student a copy of Message A.

Materials

For each student:

- Message A Page
- Order of Frequency Usage Table

Suggest that they look over the message for a few minutes. Then hold a short conversation that reviews what they observed. Comments might include statements such as:

- There are five sentences in the message.
- There are 314 letters in the message.

Chances are the students will not have decoded the message up to this point. The teacher may choose to offer the following prompts.

- If a word has only one letter, what are the possible letter choices?

- Are there any 3-letter patterns that show up frequently in the message? Underline them. What are some possibilities for common 3-letter words (the teacher may have to suggest words like "and, how, the, why")? Choose one of these words and substitute its letters for the appropriate letters of a frequent 3-letter combination in the coded message. If the 3-letter word you chose does not make sense when its letters replace the appropriate letters in the coded message try a different 3-letter word.

- Distribute to the students the Order of Frequency Usage for Letters in the English Alphabet.

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

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Since there are five sentences in the message, form teams and have each person on the team work on a sentence or two.

Let each person on the team count the number of each of the different letters in their sentence(s). When all of the counting has been completed sum up everyone's totals. For example, a = 12, b = 6, c = 1, and so on. Using the frequency list that has been provided take a guess that the most frequent letter in the coded message matches the most frequent letter in the list. If this substitution does not produce a meaningful translation try the next most frequent substitution.

- Look for frequently seen double letter combinations. Try substituting combinations like, "FF", "LL", "MM", "SS", etc.

Have the students write their translation of the coded message in the space below the message on the **Message A** page along with any other information that is requested.

Tell the students to bring their translation to the teacher when they think they have decoded the message. Those teams can then help others to decode their sentences.

Replacing coded message letter "v" with original letter "a", coded message letter "w" with original letter "b", coded message letter "x" with original letter "c", coded message letter "y" with original letter "d", etc., the decoded message reads:

The highway was filled with vehicles. Huge trucks were traveling faster than some of the cars. During a break in the line of vehicles a mother duck ventured across the lanes with her ducklings behind her. However, the babies did not waddle as fast as the mother duck and they got caught on the median between lanes of traffic. What would you do if you were in a car and observed this problem?

DEBRIEF **Activity One***:*

When all students have successfully decoded **Message A**, engage the group in a discussion of the following questions:

- **What was the first thing you did in this inquiry?**
- **What strategies were most useful in decoding the message?**
- **What was your response to the question posed in the message?**

NOTES

Activity Two: *Message B* (45 – 60 minutes)

Objectives and Standards: SL.6-8.1; MP1; 6.RP.A.3; 7.SP.A.1

The students will:

- **learn the frequency of letters used in the English alphabet**
- **use frequency analysis to help decode monoalphabetic substitution ciphers**
- **gain insights into decryption strategies**

Suggested Inquiry Approach:

Following discussion with the students bring out the point that the strategies that they used to decode the message in the previous activity work better with some messages than other messages. After this point, the students should be given the **Message B** page. As they attempt to decode **Message B** they will come to understand some of the characteristics of a message that make it difficult to decipher using the strategies that were previously used.

Materials

For each student:

- Message B Page
- Order of Frequency Usage Table
- OPTIONAL: Computer with Internet Access

The students should be encouraged to work either independently or together to decipher **Message B**. There is an optional website presented in the **Supplemental Extensions** which may aid in deciphering this message. As the students attempt to use the decoding strategies that they have previously used they may encounter some difficulties. They should be provided with enough time to explore several decoding approaches. The amount of time will vary with different groups. An indicator that can be used in deciding when to intervene is the level of frustration displayed by the students. Some consternation is acceptable as the letters in this message may not match the most frequently used letters in the English language with the most frequently found letters in the coded message. In addition **Message B** is shorter than **Message A**. This may make it more difficult to guess words in the message. Before there is too much angst, bring the group together for a review of what they have tried and what they have found.

Tell the students to bring their translation to the teacher when they think they have decoded the message. Those teams can then help others to decode their sentences.

NOTES

Replacing coded message letter "L" with original letter "A", coded message letter "M" with original letter "B", coded message letter "N" with original letter "C", coded message letter "O" with original letter "D", etc., the decoded message reads:

Air is made up of a combination of things. Two characteristics of it are that it is transparent and it has mass. Objects lighter than air float in it.

DEBRIEF **Activity Two***:*

After everyone has decoded the message engage the students in a large group discussion. Some questions that may be posed are:

- **How was Message B. different from Message A?**
- **Was Message B easier or harder to decode than Message A? Why?**
- **What strategies did you use in decoding Message B?**

Unit 1 Debrief:

- **Name three strategies that a person can employ to guess and check to see if a message can be decoded.**
- **What characteristics of a message make it difficult to decode?**

EXTENSIONS:

Optional to Decode Message B

Copy and paste the text file *Message B.txt* file into the Intercept section of the following webpage. Clicking on the Frequency button will provide students with a breakdown of the letter frequencies. They can then click on Make Substitutions to attempt to decipher the text.

http://crypto.interactive-maths.com/frequency-analysis-breaking-the-code.html

http://www.cryptoclub.org/tools/substitution_cipher.php
This website also allows students to input text to decipher.

Letter Frequency

a =	**j =**	**s =**
b =	**k =**	**t =**
c =	**l =**	**u =**
d =	**m =**	**v =**
e =	**n =**	**w =**
f =	**o =**	**x =**
g =	**p =**	**y =**
h =	**q =**	**z =**
i =	**r =**	

TRANSPARENCY MASTER