LIBRARY ALCHEMY

Combining fiction and nonfiction to promote STEM in your school.

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Lesson Plan: Spies and Secret Codes

Objective: By the end of the lesson, students will be able to:

1. Understand the historical use of spies and secret codes by governments to gather intelligence.
2. Recognize the importance of keeping communications confidential in espionage.
3. Create and use a substitution code to encode and decode messages.

Materials:

1. Paper and pencils for note-taking and message writing
2. Chart paper or whiteboard for demonstration
3. Examples of historical codes and ciphers (optional)
4. Reference books or online resources on espionage and codes (optional)
5. Code-making worksheet (template provided by teacher)
6. Code-breaking worksheet (template provided by teacher)

Introduction:

1. Begin the lesson by asking students what they know about spies and espionage. Encourage them to share any prior knowledge or experiences they have had with the topic.
2. Explain to the students that throughout history, governments have used spies to gather secret information about their enemies or rivals. Emphasize the need for spies to communicate covertly to protect sensitive information.
3. Introduce the concept of codes and ciphers used by spies in the past to encode their messages. Show examples of historical codes if available and discuss how they were used to keep communications secret.

Activity:

1. Set up a "Code-Making Center" in the library with different stations for students to work individually or in small groups.
2. Provide each student/group with a code-making worksheet and instructions on how to create a substitution code. Demonstrate the process of creating a simple substitution code on the chart paper or whiteboard.
3. Instruct students to create their own substitution code by assigning a unique symbol or letter to each letter of the alphabet. Encourage them to be creative but also clear and consistent in their substitutions.
4. Once students have created their codes, they should use them to write a secret message for other students to solve. Remind them to keep their code key (the mapping from letters to symbols) confidential.

5. Allow students to move around the Code-Making Center, exchanging their secret messages with classmates and attempting to decode messages written by others using their own codes.
6. After decoding messages, students can fill out a code-breaking worksheet to record their decoded messages and the corresponding code keys.
7. Reconvene as a class to discuss the activity. Invite students to share their experiences with creating and decoding codes. Discuss the challenges and strategies involved in both making and breaking codes.

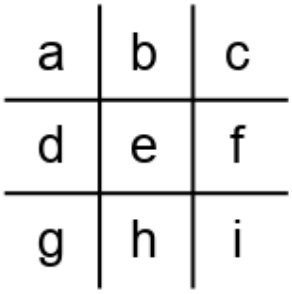
Conclusion:

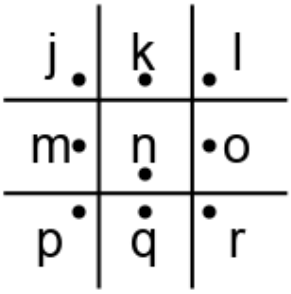
1. Summarize the key points of the lesson, emphasizing the historical significance of spies and secret codes in espionage.
2. Reiterate the importance of communication security in espionage and its relevance to historical and contemporary issues.
3. Encourage students to continue exploring the world of spies, codes, and cryptography through further reading or research.

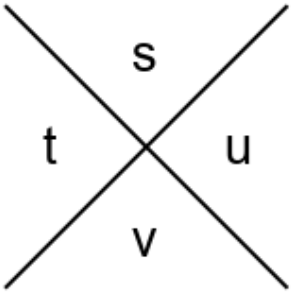
Assessment: Assessment can be informal, based on students' participation, engagement, and ability to create and decode messages using their substitution codes during the activity. Additionally, teachers can review students' completed code-making and code-breaking worksheets to gauge their understanding of the concepts covered.

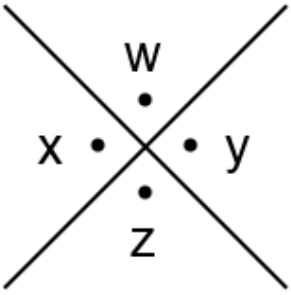
The Pig Pen Cipher

The pigpen cipher is a simple substitution cipher in which letters of an original message (plaintext) are substituted by geometric symbols creating a coded message (ciphertext).









The pigpen cipher gets its name because letters of the alphabet are separated like pigs in a pen using checkerboard and X patterns. Fragments of the checkerboard and X patterns then replace the letters of the original message. The pigpen cipher has a long history. Some historians argue the Knights Templar used the pigpen cipher during the Crusades almost a century ago.

Freemasons used the pigpen cipher so often some call it the Freemasons' cipher. Some earlier members even claimed the Freemasons invented the pigpen cipher. To this day, engravings of the pigpen cipher can be found on the tombstones of some Freemasons.

Plaintext	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
Ciphertext	⌟	⌴	⌞	⌝	⌑	⌭	⌜	⌓	⌜	⌟	⌴	⌞	⌝	⌑	⌭	⌜	⌓	⌜	∨	>	<	∧	∀	≥	≤	∧

Use the charts to create your own message using the pigpen cipher.

Simple Ciphers

A code changes words and phrases into something else for interpretation. For example, the eagle could mean the president. Or "I'm going to visit mother," could mean you are planning an escape.

Ciphers are a set of instructions (an algorithm) for converting one set of symbols (e.g., letters) into another set of symbols (e.g., numbers or pictographs). An example of a simple letter-to-number cipher is A=1, B=2, C=3, etc.

Atbash Cipher

This cipher is done by simply substituting each letter by its corresponding letter from the other end. It was originally done in Hebrew but was later adapted into English. In this cipher, Z stands for A, Y stands for B, X stands for C, and so on. You can write the letters of the alphabet from left to right (as you usually do) and then write them from right to left so that each letter is beneath its corresponding letter from the other end.

Atbash Cipher

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

Book Cipher

A book cipher disguises a message using a common book. Each word of the original message is replaced by three numbers. The first number represents the page, the second number represents the line, and the third number represents the word on that line.

The message sender and receiver use the same book as the key to encode and decode messages. It is important that both the message sender and receiver use the same edition of the same book.

For example, if I were to send the message "The owl is a wizard." I would select a book such as *Harry Potter and the Sorcerer's Stone* FIRST EDITION. Then I would search in the book for the first word – the. I can locate it on page 1, line 13, word 1. So, the code for this word would be 1.13.1. Owl can be found on page 2, line 18, word 8. Its code would be 2.18.8.

The whole sentence in code would look like 1.13.1 2.18.8 126.12.2 91.27.3 51.2.2

To create your own cipher simply grab a book and a partner and start coding.

International Phonetic Alphabet

The IPA (international phonetic alphabet), also known as the NATO phonetic alphabet, has been traditionally used to transmit messages over the radio.

Here, each letter is assigned a word. For example, A is Alpha, B is Bravo, C is Charlie, and so on. Each word is spelled out using the IPA words.

A – Alpha	*J – Juliet*	*S – Sierra*
B – Bravo	*K – Kilo*	*T – Tango*
C – Charlie	*L – Lima*	*U – Uniform*
D – Delta	*M – Mike*	*V – Victor*
E – Echo	*N – November*	*W – Whiskey*
F – Foxtrot	*O – Oscar*	*X – X-Ray*
G – Golf	*P – Papa*	*Y – Yankee*
H – Hotel	*Q – Quebec*	*Z – Zulu*
I – India	*R – Romeo*	

The International Telecommunications Union
Standard Phonetic Alphabet

Boy = Bravo Oscar Yankee

Dog = Delta Oscar Golf

Cat = Charlie Alpha Tango

Lesson Plan: Introduction to Chemistry

Making GAK

Objective: By the end of the lesson, students will be able to:

1. Understand the role of chemists in studying chemicals, elements, and substances.
2. Recognize the importance of experimentation in chemistry and the possibility of creating new substances through chemical reactions.
3. Engage in a hands-on activity to create a simple polymer substance, GAK, using liquid starch and white school glue.

Materials:

1. Liquid starch
2. White school glue
3. Food coloring (optional)
4. Mixing bowls and spoons
5. Measuring cups and spoons
6. Plastic zip-lock bags (for storing GAK)
7. Protective aprons or smocks (optional)

Introduction:

1. Begin the lesson by asking students what they know about chemistry. Encourage them to share any prior knowledge or experiences they have had with the topic.
2. Explain to the students that chemists are scientists who study the properties and behaviors of chemicals, elements, and substances that make up our world.
3. Emphasize the importance of experimentation in chemistry, where chemists observe and test how different chemicals react with each other. Mention that sometimes these reactions can lead to the creation of entirely new substances.

Activity: Making GAK

1. Gather the materials needed for making GAK and set up a workspace where students can work individually or in small groups.
2. Provide each student/group with equal parts liquid starch and white school glue, along with mixing bowls and spoons.
3. Instruct students to pour equal parts of liquid starch and white school glue into their mixing bowls. If desired, they can add a few drops of food coloring to the glue for color.
4. Encourage students to mix the ingredients together thoroughly using their spoons. They should notice changes in the mixture's consistency as they continue to mix.

5. As the mixture starts to form a slimy, stretchy substance, guide students to observe and describe its properties. Discuss how the combination of liquid starch and glue creates a polymer substance known as GAK.
6. Allow students to explore the properties of GAK by stretching, squishing, and molding it with their hands. Encourage them to observe how it behaves and compare it to other materials they are familiar with.
7. After experimenting with their GAK, instruct students to store it in plastic zip-lock bags for future use.

Conclusion:

1. Summarize the key points of the lesson, emphasizing the role of chemists in studying chemicals and experimenting to create new substances.
2. Reiterate the importance of observation and exploration in science, as demonstrated through the GAK-making activity.
3. Encourage students to continue exploring chemistry and conducting simple experiments at home or in the classroom.

Assessment: Assessment can be informal, based on students' participation, engagement, and ability to follow instructions and engage in the GAK-making activity. Additionally, teachers can observe students' interactions with GAK and their ability to describe its properties and behavior during the activity.

Additional Activity

Making Bouncy Balls with Glue and Borax

Introduction: In this activity, we will be exploring chemistry by creating bouncy balls using a combination of glue and borax. The chemicals in these ingredients will bond together to form a new substance, demonstrating basic principles of chemistry in action.

Materials:

- 1 tbsp. Elmer's white glue
- Food coloring
- 1/2 tsp. Borax powder (found in the laundry detergent aisle of most larger stores)
- 3 tbsp. Cornstarch
- 4 tbsp. Warm water
- Two cups or bowls for mixing
- Paper towels (for wiping hands)

Procedure:

1. **Prepare Ingredients:**

- In one cup or bowl, combine warm water, cornstarch, and borax powder. Stir well to ensure all ingredients are thoroughly mixed.
- In another cup or bowl, pour the white glue. Add several drops of food coloring into the glue and stir until the color is evenly distributed.

2. **Combine Ingredients:**
    - Give the water/cornstarch/borax mixture a good stir to prevent settling. Then, pour this mixture into the colored glue.
3. **Mix Thoroughly:**
    - Use a spoon or stirring stick to mix the ingredients together. You'll notice the mixture immediately starts to clump together.
4. **Form the Ball:**
    - Once the ingredients are well mixed and have formed into a slimy glob, take it out of the liquid and begin rolling it between the palms of your hands to form a ball.
    - Initially, the mixture may feel sticky, so keep a paper towel handy to wipe off your hands occasionally. Continue rolling the mixture until it starts to form a smooth, rubbery ball.
    - Note: Using just the palms of your hands may work better than using your whole hands and fingers.
5. **Final Touches:**
    - Once the stickiness is gone and you have a nice smooth ball, you're done! Your homemade bouncy ball is ready to bounce away!

Conclusion: Congratulations on successfully making your own bouncy balls using glue and borax! Through this activity, you've witnessed the chemical reactions that occur when these ingredients are combined, showcasing the fascinating world of chemistry in action. Feel free to experiment with different colors and proportions to create your own unique bouncy balls. Enjoy bouncing!

Lesson Plan: Exploring Bubbles and Surface Tension

Objective: By the end of the lesson, students will be able to:

1. Understand the concept of surface tension and its role in bubble formation.
2. Explore the science behind bubble-making using a homemade bubble solution.
3. Create and experiment with giant bubbles using DIY bubble wands.

Materials:

- 6 cups distilled or purified water
- 1/2 cup cornstarch
- 1 Tbs. baking powder
- 1 Tbs. glycerine (or corn syrup as a substitute)
- 1/2 cup blue dish soap (e.g., Dawn Ultra, Dawn Pro, Joy detergent)
- Cotton kitchen string (around 54 inches)
- 2 sticks (each 1-3 feet long)
- Metal washer
- Mixing bowls
- Stirring utensils
- Paper towels (for cleanup)

Introduction: Begin the lesson by discussing with students the concept of surface tension and how it relates to water molecules. Explain that surface tension is the property of the surface of a liquid that allows it to resist an external force due to the cohesive nature of its molecules. Introduce the idea that soap molecules disrupt surface tension, allowing bubbles to form.

Activity: Making and Exploring Bubbles

1. **Preparing the Bubble Solution:**
    - In a mixing bowl, combine the distilled or purified water with the cornstarch, baking powder, and glycerine. Stir well to ensure all ingredients are thoroughly mixed, without creating tiny bubbles.
    - Add the blue dish soap to the mixture and continue stirring until the solution is smooth and uniform. Avoid creating bubbles while mixing.
2. **Creating Giant Bubble Wands:**
    - Provide each student or group with cotton kitchen string, two sticks, and a metal washer.
    - Instruct students to tie one end of the string to the end of one stick securely.

- Thread the metal washer onto the string and tie the other end of the string to the end of the second stick, leaving around 36 inches of string between the two sticks. Tie the remaining 18 inches of string to the end of the first stick, creating a triangle shape with the string.

3. **Exploring Bubble Formation:**
    - Discuss with students the process of bubble formation and how it relates to surface tension and soap molecules.
    - Demonstrate how to dip the bubble wand into the prepared bubble solution, ensuring that all the string is completely immersed.
    - Slowly pull the wand up out of the bubble mix while separating the sticks, forming a triangle shape with the string and a bubble in the middle.
    - Encourage students to experiment with different techniques for creating giant bubbles, such as stepping backward or moving the wands to vary the size and shape of the bubbles.

Conclusion: Reflect on the activity with students by discussing their observations and experiences with making and exploring bubbles. Emphasize the role of surface tension and soap molecules in bubble formation. Encourage students to think about other everyday phenomena that involve surface tension and how they can be explored through scientific inquiry.

Extension: Challenge students to conduct further experiments with bubbles, such as testing different bubble solutions or exploring the effects of temperature on bubble formation. Encourage them to record their observations and hypotheses in a science journal.

Lesson Plan: Exploring the Science of Fingerprints

Objective: By the end of the lesson, students will be able to:

1. Understand the importance of fingerprints in forensic science and criminal investigations.
2. Explore the science behind detecting and analyzing different types of fingerprints.
3. Investigate factors that affect the quality of fingerprint evidence, such as surface texture and skin condition.

Materials:

- Raw cacao powder
- Baby powder
- Small bowls (2)
- Clear tape
- Black paper
- White paper
- Smooth glass or metal surface
- Fine brush with soft bristles (e.g., makeup brush)
- Dust cloth
- Water
- Soap
- Hand lotion

Preparation:

1. Pour a little cacao powder into one small bowl and a little baby powder into the other.
2. Wipe the smooth glass or metal surface with the dust cloth to ensure it is clean.

Procedure:

Introduction to Fingerprints:

1. Begin the lesson by discussing the importance of fingerprints in forensic science and criminal investigations. Explain that fingerprints are unique to each individual and can be used as evidence to identify suspects.
2. Introduce the three types of fingerprints: fingerprint imprints, patent fingerprints, and latent fingerprints. Explain the differences between them, emphasizing that latent fingerprints are invisible but still present.

Detecting Latent Fingerprints:

1. Explain to students that latent fingerprints are made up of natural oils, sweat, and other substances from the skin. Discuss the methods used to make latent fingerprints visible, such as dusting with powder or using chemical reactions.
2. Demonstrate the dusting method using cacao powder or baby powder on the smooth glass or metal surface. Show students how to apply the powder with a fine brush and gently sweep it over the area of the fingerprint.

Activity:

1. Have each student choose one finger and press it firmly onto the clean smooth surface. Instruct them to remember where they placed their fingerprint.
2. Depending on the color of the surface, students will use either cacao powder (for dark surfaces) or baby powder (for light surfaces) to dust over the area of the fingerprint.
3. Encourage students to carefully observe and record their observations as they dust the powder over the fingerprint. Ask them to note any changes in visibility and detail.
4. After dusting, have students gently blow off excess powder and check their results. Instruct them to use clear tape to lift the developed fingerprint from the surface and transfer it onto a piece of paper.
5. Have students wash their hands thoroughly with warm water and soap, then repeat steps 1-4 with the same finger. Compare the visibility and quality of the fingerprint with the previous one.
6. Finally, have students apply hand lotion to their hands and repeat steps 1-4 again. Compare the resulting fingerprint with the previous ones and discuss the differences.

Conclusion:

1. Lead a discussion on the observations and results of the activity. Emphasize the impact of surface texture and skin condition on the quality of fingerprint evidence.
2. Reinforce the importance of careful observation and attention to detail in forensic science investigations.
3. Encourage students to consider the broader applications of fingerprint analysis in real-world scenarios.

Extension:

1. Challenge students to conduct further experiments with different surface textures or materials to see how they affect fingerprint visibility.
2. Encourage students to explore their own homes to find and analyze fingerprints on various surfaces. Discuss the potential significance of finding fingerprints in different locations.

Lesson Plan: Hot Dog Mummies

Objective: By the end of the lesson, students will be able to:

1. Understand the process of mummification and how a desiccant works to remove moisture and preserve organic materials.
2. Conduct a hands-on experiment to mummify a hot dog and observe changes over time.
3. Record and analyze data to draw conclusions about the effectiveness of the mummification process.

Materials:

- Disposable gloves (3 pairs)
- Paper towels (3)
- Meat hot dog
- Ruler (metric)
- Piece of string or yarn (at least 10 cm long)
- Kitchen scale
- Airtight plastic storage box with lid
- Baking soda
- Lab notebook

Procedure:

Introduction to Mummification and Desiccation:

1. Begin the lesson by discussing mummification and its importance in preserving organic materials, particularly in ancient Egypt. Explain that mummification involves removing moisture from the body to prevent decay.
2. Introduce the concept of a desiccant, explaining that it is a substance used to absorb moisture and promote drying.

Hands-on Activity: Making a Mummy

1. Divide the students into pairs or small groups and distribute the materials.
2. Instruct students to put on a pair of disposable gloves and place a paper towel on their work surface. Have them measure the length and circumference of the hot dog and record the data in their lab notebooks.
3. Prepare the hot dog for the mummification process by placing it in an airtight plastic storage box filled with baking soda. Seal the box and place it in a shaded, indoor location.

4. After one week, have students remove the hot dog from the baking soda, gently tap off excess powder, and measure its length, circumference, and weight. Record the data in their lab notebooks and observe any changes in the hot dog's appearance.
5. Discard the old baking soda, clean the box, and repeat the process with fresh baking soda. Seal the box and leave it for another week.
6. After the second week, repeat the measurements and observations. Encourage students to compare the data from both weeks to analyze the effectiveness of the mummification process.

Discussion and Analysis:

1. Lead a discussion on the observations and results of the experiment. Ask students to describe any changes they observed in the hot dog over the two-week period.
2. Explain how the baking soda acted as a desiccant, absorbing moisture from the hot dog and promoting dehydration, which is essential for mummification.
3. Discuss the significance of the changes observed in the hot dog and relate them to the process of mummification used by ancient civilizations.
4. Have students draw conclusions about the effectiveness of the mummification process based on their data and observations.

Conclusion:

1. Summarize the key points of the lesson, emphasizing the role of desiccation in mummification and the importance of preserving organic materials.
2. Encourage students to reflect on what they learned and how it relates to ancient Egyptian culture and history.
3. Reiterate the scientific principles behind mummification and the use of desiccants to promote preservation.

Extension:

1. Challenge students to research other methods of mummification used by ancient civilizations and compare them to the process used in the experiment.
2. Explore the cultural significance of mummification in ancient Egypt and its connections to religion and society.
3. Have students create visual representations of the mummification process, such as diagrams or models, to demonstrate their understanding.

Archaeology Adventure: Piecing Together the Past

Objective: By the end of the lesson, students will be able to:

1. Understand the work of archaeologists and the process of piecing together broken artifacts.
2. Develop problem-solving skills by reconstructing shattered pottery fragments.
3. Appreciate the importance of careful excavation and artifact preservation.

Materials:

- Old clay flowerpots and containers of different shapes (pre-smashed)
- White glue
- Large tubs filled with soil (for simulated dig site)
- Brushes (for dusting off artifacts)
- Small containers or bags (for collecting fragments)
- Notebook and pencils (for recording observations)

Procedure:

Introduction to Archaeology:

1. Begin the lesson by introducing the field of archaeology and explaining the role of archaeologists in uncovering and studying ancient artifacts.
2. Discuss the importance of artifacts in understanding past civilizations and cultures, emphasizing that archaeologists often find broken pieces of pottery that they must reconstruct to learn more about the objects' shapes and uses.

Setting Up the Learning Station:

1. Arrange several large tubs filled with soil in a designated area indoors. These will serve as simulated dig sites.
2. Scatter the pre-smashed pottery fragments throughout the soil in each tub, ensuring that some pieces are buried deeper than others and that some fragments are missing to mimic a real archaeological site.

Artifact Reconstruction:

1. Divide students into small groups and assign each group to a tub of soil.
2. Provide students with brushes and instruct them to carefully excavate the soil to uncover pottery fragments. Encourage them to handle the artifacts gently and use brushes to dust off any dirt or debris.
3. As students uncover pottery fragments, have them collect the pieces in containers or bags and bring them back to their workspace.

4. Provide students with white glue and instruct them to carefully piece together the fragments to reconstruct the original objects. Encourage them to refer to the shapes and patterns of the fragments to determine how they fit together.
5. Emphasize the importance of patience and precision in reconstructing the artifacts, as archaeologists often spend hours piecing together broken pottery to uncover valuable information about ancient cultures.

Discussion and Reflection:

1. After the activity, lead a discussion on the challenges and discoveries students encountered during the artifact reconstruction process. Encourage them to share their observations and insights about the shapes and potential uses of reconstructed objects.
2. Discuss the importance of preserving archaeological sites and artifacts for future study and understanding of history.
3. Ask students to reflect on the skills they developed during the activity, such as problem-solving, teamwork, and attention to detail.

Conclusion:

1. Summarize the key points of the lesson, reinforcing the importance of archaeology in uncovering and preserving the past.
2. Encourage students to continue exploring the world of archaeology and to appreciate the rich history and culture of ancient civilizations.
3. Consider displaying the reconstructed artifacts in the classroom or school to showcase students' work and celebrate their achievements in piecing together the past.