6-8 Lesson Plan

The Everyday Science of Your Brain

Lesson Overview:
In this lesson, students will learn which parts of their brain help them learn and remember. They will learn the science behind short- and long-term memory and test themselves to see how well they can remember certain information. They will also test different strategies for improving their memory and try to determine which strategies work best for them and why. Finally, they will create a PowerPoint presentation that explains the science behind memory and how this science can be useful in their everyday lives.

Learning Objectives:
Students will be able to:

- Explain the basic concepts of memory.
- Be able to identify differences between short- and long-term memories.
- Test several strategies designed to improve memory.
- Summarize how the science behind memory can be useful in their everyday lives.

Academic Standards

National Science Education Standards

- Students should develop general abilities, such as systematic observation, making accurate measurements and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures. (p. 145)
- The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes. (p. 145)
- Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge. (p. 145)
- Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a

simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. (p. 145)

- With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (p. 148)
- Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms. Behavioral response is a set of actions determined in part by heredity and in part from experience. (p. 157)

Benchmarks for Science Literacy

- Scientific investigations usually involve the collection of relevant data, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected data. 1B/M1b
- If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one variable. It may not always be possible to prevent outside variables from influencing an investigation (or even to identify all of the variables). 1B/M2ab

Time frame:
This lesson can be completed in one to two class periods

Background Information for the Teacher:
The human brain has been called the most complex living structure known in the universe. Although it has the same general structure as the brains of other mammals, it is over three times as large as the brain of a typical mammal with an equivalent body size, and much more complex. It is a complex organ, with an estimated 100 billion neurons passing signals to each other via as many as 1,000 trillion synaptic connections. It continuously receives and analyzes sensory information, responding by controlling all bodily actions and functions. It is also the center of higher-order thinking, learning and memory, and gives us the power to think, plan, speak, imagine, dream, reason and experience emotions.
Memory is the ability of our brain to recall information. When we think we have forgotten something, we really have either not stored it properly or cannot recall the information. Short-term memory receives information for a very limited time and usage. Examples include looking up a phone number to order a pizza and then forgetting it once it's used. There was never an intention to store that number into long-term memory. If it is intended to be stored, we must organize it, repeat it and work on moving it into our long-term memory. Long-term memory is the capacity that allows us to recall information from day to day, a week later, and a year later. The information in our long-term memory is information that has been organized and stored properly. However, we still have to fight forgetting so we need to review and use the information.

The transfer of information to long-term memory for more permanent storage can be facilitated or improved by mental repetition of the information or, even more effectively, by giving it a meaning and associating it with other previously acquired knowledge. Motivation is also a consideration, in that information relating to a subject of strong interest to a person is more likely to be retained in long-term memory.

Encoding is the first step in creating a memory. It begins with perception. An example would be the memory of meeting a new friend. When you met that person, your visual system registered physical

features, such as the color of their eyes and hair. Your auditory system may have picked up the sound of their voice. You may have also noticed how their perfume smelled. Each of these separate sensations traveled to the part of your brain called the **hippocampus**, which integrated these perceptions into one single experience -- your experience of that specific person. Experts believe that the hippocampus, along with another part of the brain called the **frontal cortex**, is responsible for analyzing these various sensory inputs and deciding if they're worth remembering. If they are, they may become part of your long-term memory. As indicated earlier, these various bits of information are then stored in different parts of the brain. How they are later identified and retrieved to form one memory, however, is not yet known.

Although a memory begins with perception, it is encoded and stored using the language of electricity and chemicals. Nerve cells connect with other cells at a point called a **synapse**. All the action in your brain occurs at these synapses, where electrical pulses carrying messages leap across gaps between cells. The electrical firing of a pulse triggers the release of chemical messengers called **neuro-transmitters**. These neurotransmitters diffuse and attach themselves to neighboring cells. Each brain cell can form thousands of links like this, giving a typical brain about 100 trillion synapses. The parts of the brain cells that receive these electric impulses are called **dendrites**, feathery tips of brain cells that reach out to neighboring brain cells.

The connections between brain cells change all the time. Brain cells organize themselves into groups that specialize in different kinds of information processing. As one brain cell sends signals to another, the synapse between the two gets stronger. The more signals sent between them, the stronger the connection grows. With every new experience, your brain slightly rewires its physical structure. In fact, how you use your brain helps determine how your brain is organized. This flexibility, called **plasticity**, can help your brain rewire itself if it is ever damaged. As we learn new information and have different experiences, changes occur at the synapses and dendrites and more connections in our brain are created. The brain organizes and reorganizes itself in response to our experiences, forming new memories.

These changes are reinforced with use, so that as we learn and practice new information, circuits of knowledge and memory are built in the brain. If we play a piece of music over and over, for example, the repeated firing of certain cells in a certain order in the brain makes it easier to repeat this firing later on. So we get better at playing the music and can play it faster and with fewer mistakes. Yet if we stop practicing for a period of time and try to play the piece, our brain has already begun to forget what you once knew so well.

To properly encode a memory, we must first be paying attention. Since we cannot pay attention to everything all the time, most of what we encounter is simply filtered out, and only a few stimuli pass into your conscious awareness. If we remembered every single thing that we noticed, our memory would be full early every morning!

Materials for the teacher:

- 17 unrelated small items that could be placed on a desk
- A blanket or cloth
- Stopwatch

Materials for each student:

- "Memory Study" student activity sheet
- "Will You Remember?" student activity sheet
- Access to the Internet
- Index cards

Classroom Activities:

Engage

1. Distribute an index card to each student and ask them to write down four pieces of information:
    a. What they ate for breakfast exactly seven days ago.
    b. What you (their teacher) wore yesterday.
    c. What they did for their eighth birthday party.
    d. The last person they saw before they entered your classroom.

2. After a few minutes, review answers. How many answers did students know? Ask students what all of the questions have in common. The answer is that they are all based on student's memories and that is what they are going to learn about in this lesson.

3. Ask students what it means to them when someone uses the phrase "good memory." What makes someone have a good memory? What part of their body do students think is responsible for "memory?"

Explore

4. Divide students into groups of five and assign one of them as the recorder and the other four as the test subjects. Distribute the "Memory Study" activity sheet to the recorder *only.* One at a time (and not within listening range of the other subjects) direct the recorder to read the list of words on the "Memory Study" to each subject. Tell the subjects that they will be asked to read back as many words as they can once the list is finished. Once the list has been completely read, have each subject read back all of the words that they remember while the recorder writes them down. Repeat this exercise with all four subjects.

5. Once the exercise is finished, direct each group to analyze their results by calculating the percentage of recall for each word and plotting/curving the results on the x/y axis at the bottom of the activity sheet.

6. Compare graphs with other groups and draw conclusions about the curves. Typically words read first and last are remembered better than those read in the middle of the list. Ask students why that might be. One reason might be that the words read first were the ones that the subject was able to place into long-term memory while the words read last are the ones that are still in the subject's short-term memory. Other reasons might be through association. For example, if you

have a fish in the classroom, the word fish might be easy for all students to associate with and/or visualize.

Engage

7. Ask students if they have any idea what part(s) of the brain is responsible for memory. Direct students to an online diagram of the brain to help them hypothesize. A detailed online diagram can be found at http://www.nlm.nih.gov/medlineplus/ency/imagepages/1074.htm.

Explore

8. Share with students that experts believe that memory is a brain-wide process. When we try to access a memory, it is actually reconstructed from many different parts of our brain. The hippocampus, which is located in the temporal lobe, plays one of the largest roles in memory. Explain to students that the hippocampus is responsible for consolidating short-term memories into long-term. Other parts of the brain are also involved in memory. Working memory (an aspect of short-term memory) is done in the prefrontal cortex and long-term memories are stored in the neocortex. Point out that memories with an emotional connection are linked to the amygdale, and procedural memories, which use the body, are stored in the cerebellum. Additional information to share with students can be found in the "Background Information" section above.

9. Explain to students that how strong a memory remains in their brain depends on the strength of the synapse between the nerve cells associated with the memory. The more they practice or think about a piece of information stored in their brains, the more that particular synapse is going to be used. Examples include a piece of music they might play or a set of facts they must memorize for a test. As they practice over and over, it becomes easier and they become better at it. That's because their brain is using the synapse more frequently and so the memory grows stronger. If they do not access the memory often, the synapse begins to weaken. This may cause them to forget, or have a hard time remembering a memory that has not been accessed in some time.

10. Ask students if they know what short- and long-term memory are. Share definitions from the "Background Information" above. Ask students to share examples of short- and long-term memory, reminding students that only seven items can remain in our short -term memory at one time before they are either forgotten or moved to long-term memory.

Elaborate

Note: Before this part of the lesson, place 17 small items on a desk and hide them underneath a blanket or cloth. If items are not available, you can write unrelated words on 17 index cards or cut out and paste 17 unrelated magazine pictures on index cards.

11. Ask students what techniques they currently use to try to help them remember things they have to do or information for a test. Then tell students that they are going to test different memory techniques and report back to the group if and how the technique helped their memories. The idea behind using these memory techniques is to encode difficult-to-remember information in a way that is much easier to remember by creating a pattern or image to help them do so.

12. Distribute the "Will You Remember?" student activity sheet and review the four different memory techniques with students. They are:

a. **Going on a Trip**- This technique is a form of visualization but it is related to an imaginary trip you will take. Once you know what it is you have to remember, imagine yourself going on a trip and either taking or doing what needs to be remembered along the way. You can even imagine yourself packing items in a suitcase! As with visualization, the technique works because you are coding what you have to remember using mental images
b. **Chunking**- Ever wonder why local phone numbers are seven digits long? Researchers have found that typically people are only capable of remembering a sequence of seven things at any given point in time and that we are able to better remember when those seven things are chunked into smaller groups. When you chunk, try to organize the information into smaller chunks that go together.
c. **Acrostic** - An acrostic is a type of memory technique that uses the first letter in each word for a new word or phrase that will help us remember information. One famous acrostic is ROY G BIV to remember the colors of the rainbow (red, orange, yellow, green, blue, indigo and violet). An acrostic is a way to organize information into a pattern that our brains can more easily remember.
d. **Acronym**- An acronym is another memory technique where we make up a sentence that makes sense to us to remember information that may not be easy to remember. An example is using "My Very Excellent Mom Just Served Us Nine Pizzas" to remember the order of planets from the sun (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto). This is another way to organize information into a pattern that our brains can more easily remember.

13. Tell student groups that they will be viewing 17 different items. They must use one of the memory techniques on the activity sheet to try to remember as many items as they can. Encourage them to choose the technique that they believe will give them the greatest result. Have students get out a sheet of paper and a pen. Direct them to write the memory technique they have chosen at the top of the paper. (You may want to ask one group of students not to use any technique at all so you have a control group.)

14. Then set the stopwatch for one minute and unveil the 17 items. After one minute, cover up the items and direct students to write down as many items as they can remember.

Explain

15. Ask students to compare and explain results. Can they notice any patterns in the results? Did one technique seem to work better than the others? What techniques did those students who remembered the highest number of items use? Given what they know, which technique do they believe would work best for them and why?

Evaluate

16. To evaluate their understanding, challenge students to design a PowerPoint presentation that answers the following questions:
    a. How do we remember information?
    b. What is the difference between short- and long-term memory?
    c. What is one technique for helping to remember information and why does it work?
    d. How can I use this information in my everyday life?

Scoring Key for Evaluation:

1. Encoding is the first step in creating a memory. It begins with perception. The hippocampus integrates our perceptions into one single experience and, along with the frontal cortex, decides if it is worth remembering. If it is, it may become part of our long-term memory. These various bits of information are then stored in different parts of the brain. A memory is then encoded and stored using the language of electricity and chemicals. Nerve cells connect with other cells at a point called a synapse. Brain cells organize themselves into groups that specialize in different kinds of information processing. As one brain cell sends signals to another, the synapse between the two gets stronger. The more signals sent between them, the stronger the connection grows. As we learn new information and have different experiences, changes occur at the synapses and dendrites and more connections in our brain are created. The brain organizes and reorganizes itself in response to our experiences, forming new memories. These changes are reinforced with use, so that as we learn and practice new information, circuits of knowledge and memory are built in the brain.
2. Short-term memory receives information for a very limited time and usage. There was never an intention to store that number into long-term memory. If it is intended to be stored, we must organize it, repeat it and work on moving it into our long-term memory. Long-term memory is that capacity that allows us to recall information from day to day, a week later, and a year later. This information has been organized and stored properly. However, we still have to fight forgetting so we need to review and use the information.
3. Answers will vary.
4. Answers will vary but may include that organizing information into patterns so that the brain can organize it will help us remember information; sending the same signal repeatedly can strengthen the synapse and help us remember; and learning information for several consecutive days before we need to retrieve it can help store it in our long-term memory.

Memory Study student activity sheet

1. In your group, decide who will be the recorder and who will be the test subjects.

2. If you are the recorder, you should have this activity sheet. No one else in the group should have it!

3. Read the list of words below to each of your fellow group members, one at a time. Tell each subject they will be asked to read back as many words as they can. Make sure the other group members cannot hear you.

4. As each subject reads you the words, record them in the appropriate space. Assign each word a number and calculate the percent of recall for each word.

5. Then plot the results on the graph below. The X axis will be the position/number of the word you read and y axis will be the % recall. Once you plot, see if you can notice any patterns.

Word List: ear, throne, octopus, focus, short, niece, sink, anyway, life, candid, soda, mature, whole, friend, blade

Design Note: Insert blank line graph with "word position" as the x axis (numbered 1-15) and "% recall" as the y axis (numbered 0-100)

Will You Remember? Student Activity Sheet

Do you have trouble remembering information? There are many techniques that you can use to help improve your memory! These techniques encode difficult-to-remember information in a way that is much easier for us to remember by creating a pattern or image that our brains can organize. Read the four different memory techniques below. Then choose the one you believe will best help you remember a group of unrelated items that your teacher will show you.

Going on a Trip- This technique is a form of visualization related to an imaginary trip you will take. Once you know what it is you have to remember, imagine yourself going on a trip and either taking or doing what needs to be remembered along the way. You can even imagine yourself packing items in a suitcase! As with visualization, the technique works because you are coding what you have to remember using mental images.

Chunking- Ever wonder why local phone numbers are seven digits long? Researchers have found that typically people are only capable of remembering a sequence of seven things at any given point in time and that we are able to better remember when those seven things are chunked into smaller groups. When you chunk, try to organize the information into smaller chunks that go together.

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Home Connections

Parent Information:

Memory, thought and reasoning are all significantly constrained without the use of external cues. In fact, the brain can only process seven ideas at a time. So when an eighth idea comes along we must offload one into long-term memory or to a place in our environment that will help us remember it. That place in our environment is often called a cognitive artifact. Cognitive artifacts are defined as "human-made objects, devices and systems that extend people's abilities in high-level perception; encoding and storing information from memory, as well as retrieving it from memory, thinking, reasoning, and problem-solving." One frequently used cognitive artifact is a Post-it® Note.

How does the Post-it® note help our memory? "It acts as a retrieval cue, an assist for absentmindedness," says Dr. Daniel Schacter, chairman of the psychology department at Harvard and the author of "The Seven Sins of Memory: How the Mind Forgets and Remembers." He goes on to say that the Post-it® Note works as a "prospective memory cue or an external memory aid that can compensate for the encoding failure caused by distractedness, divided attention or the fact that our mind is filled with bulky and outdated information. They're accessible and easy to use, and they take advantage of the brain's facility to remember an object's location in the three-dimensional world."

- Discuss as a family what type of cognitive artifact would work best in your home and in what situations or places you would most like to use them. Set short-term goals for using cognitive artifacts to help family members remember important information.
- Design a cognitive artifact or use an existing one for your family to use for one week. Commit to writing down everything that's important for your family to remember. See if it helps improve the family's collective memory.
- Conduct an experiment with certain family members using cognitive artifacts for one week and other family members using no external aids. What differences can you notice?