



Classroom Activity | Grades 6-8

The Everyday Science of Your Brain

GUIDING QUESTION

How can you improve your short- and long-term memory?

LEARNING OBJECTIVES

Students will be able to:

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

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.

NEXT GENERATION SCIENCE STANDARDS

- ETS1.A: Defining and Delimiting an Engineering Problem
 - 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 is likely to limit possible solutions. (MS-ETS1-1)(secondary to MS-PS3-3)
- ETS1.B: Developing Possible Solutions
 - A solution needs to be tested, and then modified on the basis of the test results, in

- order to improve it. (MS-ETS1-4) (secondary to MS-PS1-6)
- There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (MS-ETS1-2) (MS-ETS1-3) (secondary to MS-PS3-3) (secondary to MS-LS2-5)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)
- ETS1.C: Optimizing the Design Solution
 - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process- that is, some of the characteristics may be incorporated into the new design. (MS-ETS1-3)(secondary to MS-PS1-6)
 - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)(secondary to MS-PS1-6)

LESSON TIME FRAME

Two, 45 minute class periods

BACKGROUND INFORMATION

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 neurotransmitters. 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

Teacher Materials/Prep

- Print copies
 - Memory Student Capture Sheet
 - Will You Remember? Student Capture Sheet
 - Home Connections Resource to send home with students
- Print copies and cut out
 - Six Word Story Summary Student Capture Sheet
- 17 unrelated small items that could be placed on a desk
- 1 blanket or cloth
- Stopwatch

Student Materials

- Six Word Story Student Capture Sheet
- Memory Study Student Capture Sheet
- Will You Remember? Student Capture Sheet
- Home Connections Resource
- Access to the Internet
- Index cards

CLASSROOM ACTIVITY

Day 1

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. 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

1. 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 Capture 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.
2. 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 capture sheet.
3. 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.

Day 2

Engage

1. 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

1. 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 amygdala, 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.

2. 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.
3. Ask students what they know about short- and long-term memory. 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

Teacher 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.

1. 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.
2. Distribute the Will You Remember? Student Capture 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.
3. 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.)
 4. Then set the stopwatch for one minute and unveil the 17 items all at once. After one minute, cover up the items and direct students to write down as many items as they can remember.

Explain

1. 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

1. 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?

TEACHER SCORING KEY FOR EVALUATE

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.

REFLECTION

Young scientists will reflect on their learning by completing the Six Word Story Summary. Print off the Six Word Story Summary Student Capture Sheet, cut them out, and distribute one to each student. Alternatively, students may create this reflection activity in their science journal:

SIX WORD STORY SUMMARY

Exit Ticket:

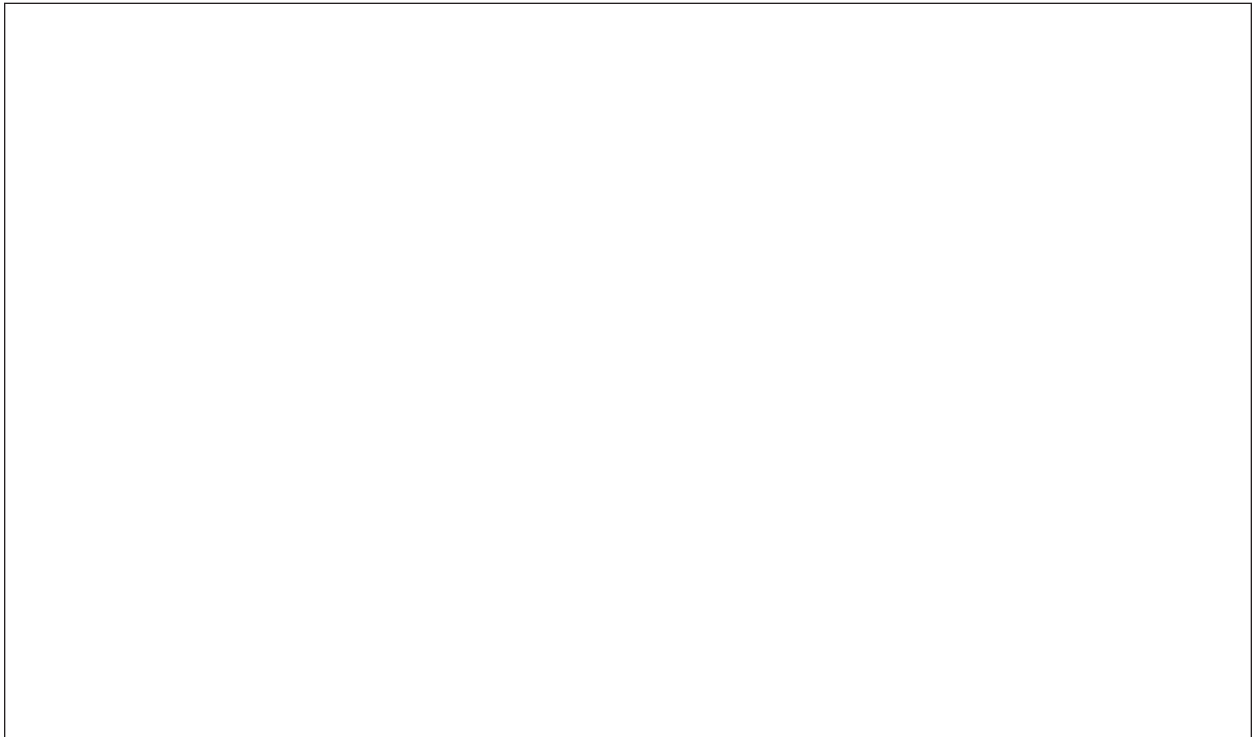
Summarize your learning in **six** words.

MEMORY STUDY

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 the Y axis will be the % recall. Once you plot, see if you can notice any patterns.

Word List: ear, throne, octopus, focus, short, niece, sank, 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 “% Recalled” as the Y axis (numbered 0-100).



WILL YOU REMEMBER?

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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SIX WORD STORY SUMMARY

Exit Ticket: Summarize your learning in **six** words.

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HOME CONNECTIONS

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 sticky note.

How does the sticky 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 sticky 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?