Classroom Learning Theories: Learning for Life and for Teaching (Beta Version)

CLASSROOM LEARNING THEORIES: LEARNING FOR LIFE AND FOR TEACHING (BETA VERSION)

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PREFACE

Preface

I once had a student ask if it was okay to change their mind about something. My response was, "It is your ethical responsibility to change your mind for the rest of your life." As lifelong learners, we should constantly grow in knowledge and understanding. With new knowledge comes the responsibility to reflect, reassess, and, when necessary, readjust our thinking, beliefs, and behaviors.

Learning is a joy, a reward in itself, and the driving force behind personal and collective progress. As educators, we not only teach subjects but also foster the processes that enable students to learn effectively. Learning about how we learn is essential to unlocking our own potential and empowering others to do the same. For me, teaching this subject has been transformative. Over the years, my beliefs, values, and ways of being have evolved dramatically, shaped by the privilege of guiding others. I hope this evolution never stops because I strive for excellence—not just for myself, but for you, the learners, who possess untapped potential you may not yet recognize.

Grounded in theoretical and evidence-based practices, this book provides a comprehensive overview of how students learn. By adopting an integrated approach, it explores learning and teaching from both learners and teachers' perspectives. Although its primary goal is to equip K-12 preservice teachers with the tools and knowledge to create positive, effective, and impactful learning environments for their future students, the principles are broadly relevant and extend far beyond the classroom. Learning and teaching are foundational to all relationships and life contexts.

In the fall of 2024, I began exploring Open Educational Resources (OER), compiling, and adapting this material, ensuring it is comprehensive, aligned with course goals, and accessible to all students. This resource remains a work in progress, reflecting our shared journey of growth, and I am honored to share it with you.

I invite you to join me in this learning adventure. Together, let's embrace the joy of learning and its potential to transform not only ourselves but also the lives of those we teach.

Are you using this textbook in your class? Tell us!

INTRODUCTION

Introduction

The book begins with foundational insights into the neuroscience of learning, serving as an overarching framework for the theoretical concepts that follow. It then explores how learners develop cognitively and socially, highlighting the role of neurodiversity in shaping individual learning differences. Alongside this, it examines key teaching strategies involved in creating positive classroom environments, fostering student motivation, managing behavior, and employing effective assessment practices.

Building on this foundation, the book delves into three major learning theories—Behaviorism, Cognitivism, and Constructivism. These theories serve as lenses through which readers can synthesize and apply the concepts discussed throughout the text. The book concludes by guiding readers to integrate these theories with practical strategies, enabling them to connect theoretical knowledge to real-world learning and teaching practices.

To enhance your learning experience, each chapter follows a consistent structure designed to make the content accessible and engaging. All chapters will include the green, orange, and red boxes of information described below, and most will also include the purple and blue boxes. Use these boxes as tools to help you gain the greatest benefit from the course readings.

Learning Objectives

Each chapter begins with clearly stated learning objectives, outlining what you should be able to do after completing the section. Use the objectives in the green boxes as a study guide to help you focus your attention as you read and assess your understanding as you progress through each section.

Watch It

Look for purple boxes containing links to external videos. These resources provide deeper insights into the topics discussed and offer visual explanations to complement the readings.

Links to Learning

Blue boxes feature links to external resources, offering illustrative examples and additional applications of the concepts. These links provide opportunities to explore topics further and develop more in-depth understanding.

Review & Practice

Orange boxes include review and practice exercises, such as short-answer questions or multiple-choice quizzes, allowing you to check your comprehension. Your instructor may also use these exercises for in-class activities or assessments.

Critical Thinking

Red boxes contain prompts designed to encourage reflection and application of the material. Use these to connect the concepts to your own experiences and to think critically about how they might apply to your future classrooms. Your instructor may also use these prompts to facilitate meaningful class discussions.

PART I

UNIT ONE: THE NEUROSCIENCE OF LEARNING

CHAPTER 1: BRAIN BASICS: KNOW YOUR BRAIN

Brain Basics: Know Your Brain

Learning Objectives

- Name and describe the basic function of the cerebrum, cerebellum, brain stem, and the limbic system
- Name and describe the basic function of the four cerebral lobes (occipital, temporal, parietal, and frontal cortex)
- Describe the structure and functions of the neuron.
- Explain the pathways of communication within and between neurons

The brain is the most complex part of the human body. This three-pound organ is the seat of intelligence, interpreter of the senses, initiator of body movement, and controller of behavior. Lying in its bony shell and washed by protective fluid, the brain is the source of all the qualities that define our humanity. It is the crown jewel of the human body. The brain is so important, in fact, that it consumes 20% of the total oxygen and calories we consume even though it is only, on average, about 2% of our overall weight (NOBA).

Figure 1.1

The brain is like a group of experts. All the parts of the brain work together, but each part has its own special responsibilities. The brain can be divided into three basic units: the forebrain, the midbrain, and the hindbrain. (See figure 2.) The hindbrain includes the upper part of the spinal cord, the lowermost part of the brain stem, and a wrinkled ball of tissue called the **cerebellum**. The lowermost part of the brain stem controls the body's vital functions such as respiration and heart rate.

Colored graphic of brain highlighting forebrain, midbrain, hindbrain sections

Figure 1.2 The cerebellum is the wrinkled ball of tissue, color-coded in yellow

The cerebellum coordinates movement and is involved in the execution of learned, rote movements. When you play the piano or hit a tennis ball, you are activating the cerebellum. The midbrain comprises the uppermost part of the brainstem, which controls some reflex actions and is part of the circuit involved in controlling eye movements, other voluntary movements, and the processing of sensations.

The forebrain is the largest and most highly developed part of the human brain; it consists primarily of the **cerebrum** and the structures hidden beneath it. (See figure 3.) When people see pictures of the brain it is usually the cerebrum that they notice. The cerebrum sits at the topmost part of the brain and is the source of conscious thoughts and actions. It holds your memories and allows you to plan, imagine, and think. It allows you to recognize friends, read, and play games.

Cerebrum and Cerebellum parts of the brain.

Figure 1.3. The cerebrum is color-coded in blue

The cerebrum is split into two halves (hemispheres) by a deep fissure. The two cerebral hemispheres communicate with each other through a thick tract of nerve fibers that lies at the base of this fissure, called the corpus callosum. Although the two hemispheres seem to be mirror images of each other, they are different. For instance, the ability to form words seems to lie primarily in the left hemisphere, while the right hemisphere seems to control many abstract reasoning skills.

For some as-yet-unknown reason, nearly all of the signals from the brain to the body and vice versa cross over on their way to and from the brain. This means that the right cerebral hemisphere primarily controls the left side of the body, and the left hemisphere primarily controls the right side. When one side of the brain is damaged, the opposite side of the body is affected. For example, a stroke in the right hemisphere of the brain can leave the left arm and leg paralyzed.

The Cerebral Cortex

Coating the surface of the cerebrum and the cerebellum is a vital layer of tissue the thickness of a stack of two or three dimes. It is called the **cortex**, from the Latin word for bark. Most of the actual information processing in the brain takes place in the **cerebral cortex**. When people talk about "gray matter" in the brain, they are talking about the cortex. The cortex is gray because nerves in this area lack the insulation that makes most other parts of the brain appear to be white. The folds in the brain add to its surface area and therefore increase the amount of gray matter and the volume of information that can be processed.

The Geography of Thought

Brain graphic labeled

Figure 1.4

Each cerebral hemisphere can be divided into sections, or lobes, each of which specializes in different functions. To understand each lobe and its specialty, we will take a tour of the cerebral hemispheres.

Frontal lobes

Figure 1.5 Frontal lobe-color-coded in orange

The two frontal lobes lie directly behind the forehead. When you plan a schedule, imagine the future, or use reasoned arguments, these two lobes do much of the work. One of the ways the frontal lobes seem to do these things is by acting as short-term storage sites, allowing one idea to be kept in mind while other ideas are considered.

Motor cortex

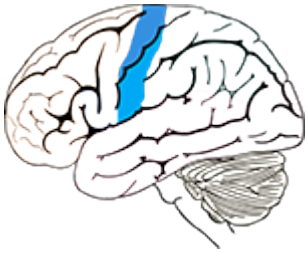

Figure 1.6 Motor cortex

In the back portion of each frontal lobe is a motor cortex, which helps plan, control, and execute voluntary movement, like moving your arm or kicking a ball.

Parietal lobes

Figure 1.7 Parietal lobes

When you enjoy a good meal—the taste, smell, and texture of the food—two sections behind the frontal lobes called the parietal lobes are at work. The parietal lobes also support reading and arithmetic.

Somatosensory cortex

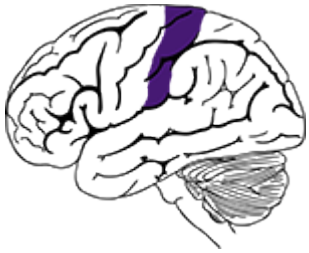

Figure 1.8 Somatosensory cortex

The forward parts of these lobes, just behind the motor areas, are the somatosensory cortex. These areas receive information about temperature, taste, touch, and movement from the rest of the body.

Occipital lobes

As you look at the words and pictures on this page, two areas at the back of the brain are at work. These lobes, called the occipital lobes, process images from the eyes and link that information with images stored in memory. Damage to the occipital lobes can cause blindness.

Figure 1.9 Occipital lobes

Temporal lobes

Figure 1.10 Temporal lobes

The last lobes on our tour of the cerebral hemispheres are the temporal lobes, which lie in front of the visual areas and nest under the parietal and frontal lobes. Whether you appreciate symphonies or rock music, your brain responds through the activity of these lobes. At the top of each temporal lobe is an area responsible for receiving information from the ears. The underside of each temporal lobe plays a crucial role in forming and retrieving memories, including those associated with music. Other parts of this lobe integrate memories and sensations of taste, sound, sight, and touch.

The Inner Brain

Deep within the brain, hidden from view, lie structures that are the gatekeepers between the spinal cord and the cerebral hemispheres. These structures not only determine our emotional state, but they also modify our perceptions and responses and allow us to initiate movements without thinking about them. Like the lobes in the cerebral hemispheres, the structures described below come in pairs: Each is duplicated in the opposite half of the brain.

The hypothalamus, about the size of a pearl, directs a multitude of important functions. It wakes you up in the morning and gets the adrenaline

Know Your Brain Inner brain labeled graphic

Figure 1.11

flowing during a test or job interview. The hypothalamus is also an important emotional center, controlling the chemicals that make you feel exhilarated, angry, or unhappy. Near the hypothalamus lies the thalamus, a major clearinghouse for information going to and from the spinal cord and the cerebrum.

An arching tract of nerve cells leads from the hypothalamus and the thalamus to the hippocampus. This tiny nub acts as a memory indexer—sending memories out to the appropriate part of the cerebral hemisphere for long-term storage and retrieving them when necessary. The basal ganglia (not shown) are clusters of nerve cells surrounding the thalamus. They are responsible for initiating and integrating movements. Parkinson's disease, which results in tremors, rigidity, and a stiff, shuffling walk, affects the nerve cells in the basal ganglia.

The Neuron

The brain and the rest of the nervous system are composed of many different types of cells, but the primary functional unit is a cell called the neuron. All sensations, movements, thoughts, memories, and feelings are the result of signals that pass through neurons. Neurons consist of three parts: the cell body, dendrites, and the axon.

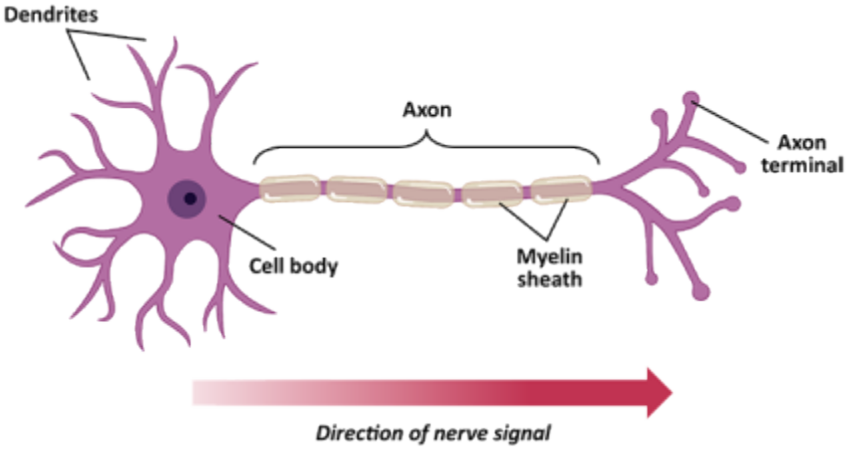

Figure 1.12

The cell body contains the nucleus, where most of the molecules that the neuron needs to survive and function are manufactured. Dendrites extend out from the cell body like the branches of a tree and receive messages from other nerve cells. Signals then pass from the dendrites through the cell body and travel away from the cell body down an axon to another neuron, a muscle cell, or cells in some other organ.

The neuron is usually surrounded by many support cells. Some types of cells wrap around the axon to form an insulating myelin sheath. Myelin is a fatty molecule which provides insulation for the axon and helps nerve signals travel faster and farther. Axons may be very short, such as those that carry signals from one cell in the cortex to another cell less than a hair's width away. Other axons may be very long, such as those that carry messages from the brain all the way down the spinal cord.

The Synapse

Know Your Brain synapse graphic

Figure 1.13

Scientists have learned a great deal about neurons by studying the synapse – the place where a signal passes from one neuron to another. When the signal reaches the end of the axon, it stimulates the release of tiny sacs called vesicles. These vesicles release chemicals known as neurotransmitters into the synaptic cleft. The neurotransmitters cross the synapse and attach to receptors on the neighboring cell. These receptors can change the properties of the receiving cell. If the receiving cell is also a neuron, the signal can continue the transmission to the next cell.

Links to Learning

1. Hand-Brain Model (Youtube)- Learn to use your fist to model the brain and use it to discuss the difference between the logical brain vs the emotional brain.
2. Debunking Myths about the Human Brain (from the Global Council on Brain Health)
3. Mapping the Brain (Nova scienceNow)- In this interactive activity from the NOVA scienceNOW website, learn about several brain mapping techniques: MRI, fMRI, PET, MEG, DTI, and probabilistic.
4. Understanding Your Brain to Help You Learn Better (by Frontiers for Young Minds)

Review & Practice

Distinguish between the cerebral cortex and the cerebrum.

An interactive H5P element has been excluded from this version of the text. You can view it

online here:
https://uark.pressbooks.pub/edlearningtheory/?p=80#h5p-2

Critical Thinking

1. Which part(s) of your brain are overactive? Underactive? Explain.
2. Hypothetically speaking, choose a region of the brain, and create a marketing advertisement to sell its attributes.
3. What structure of the brain is most responsible for stress and anxiety? Why do you think this structure of the brain is so reactive?31

This chapter was adapted from The National Institute of Neurological Disorders and Stroke (NINDS). (2024). Brain Basics: Know Your Brain | National Institute of Neurological Disorders and Stroke.

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Hovden, J., Nguyen, A., & Ortega, A. (2020). Learning to Learn. Pp. 165-176. Retrieved from Couns142_version1.pdf on January 5, 2025.

National Institute of Neurological Disorders and Stroke (NINDS). (2024). Brain Basics: Know Your Brain. Retrieved from https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-know-your-brain on January 5, 2025

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- Figure 1.7 Parietal lobes © National Institute of Neurological Disorders and Stroke is licensed under a Public Domain license
- Figure 1.8 Somatosensory cortex © National Institute of Neurological Disorders and Stroke is licensed under a Public Domain license

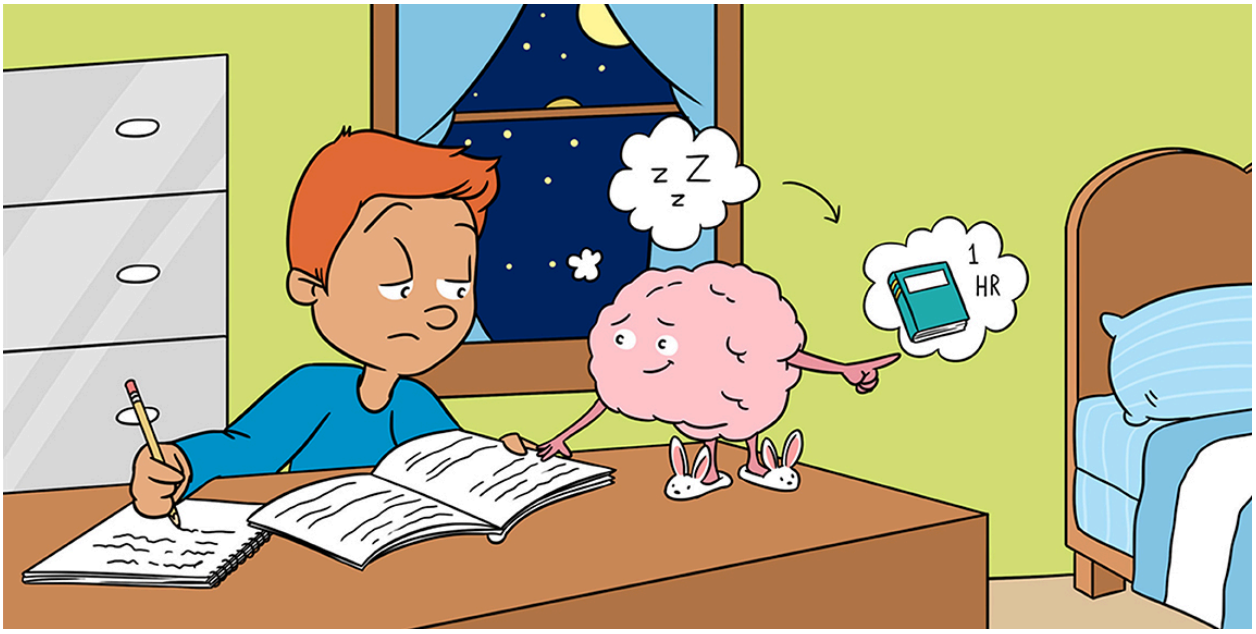
CHAPTER 2: THE LEARNING BRAIN

The Learning Brain

Learning Objectives

- Define learning from a biological perspective.
- Describe and explain what happens to the neurons in your brain when learning happens.
- Describe two strategies you can use to help yourself learn more effectively, and explain why these strategies work.
- Describe multiple active learning strategies that are likely to engage students' thinking.

The past few years have been marked by a large number of discoveries about the learning brain. Those insights have the potential to support teachers in designing even better classroom environments to help you learn better. While understanding the brain can be helpful for teachers, this knowledge can also be beneficial for you as a student.



For instance, it can encourage you to believe in your capacity to improve your own skills. Such beliefs make it more likely for you to make an effort and to make better use of supportive learning strategies[1]. In this section of the text, we briefly present some core principles of the learning brain and suggest learning strategies inspired by neuroscience for you to use in your own learning.

What Happens in My Brain When I Am Learning?

Your brain is primarily composed of about 85 billion neurons, which is more than the number of stars you can see with the naked eye in the night sky. In the previous section, we learned about brain organization and the role of specialized cells called neurons that act as messengers, sending information in the form of nerve impulses (like electrical signals) to other neurons (see Figure 1 below). For example, when you are writing, some neurons in your brain send the "move fingers" message to other neurons, and this message then travels through the nerves (like cables) all the way to your fingers.The electrical signals that are communicated from one neuron to another are, therefore, what allows you to do everything you do: write, think, see, jump, talk, compute, and so on.

1. Blanchette Sarrasin, J., Nenciovici, L., Brault Foisy, L.-M., Allaire-Duquette, G., Riopel, M., and Masson, S. 2018. Effects of inducing a growth mindset in students by teaching the concept of neuroplasticity on motivation, achievement, and brain activity: a meta-analysis. Trends Neurosci. Educ. 12:22–31. doi: 10.1016/j.tine.2018.07.003

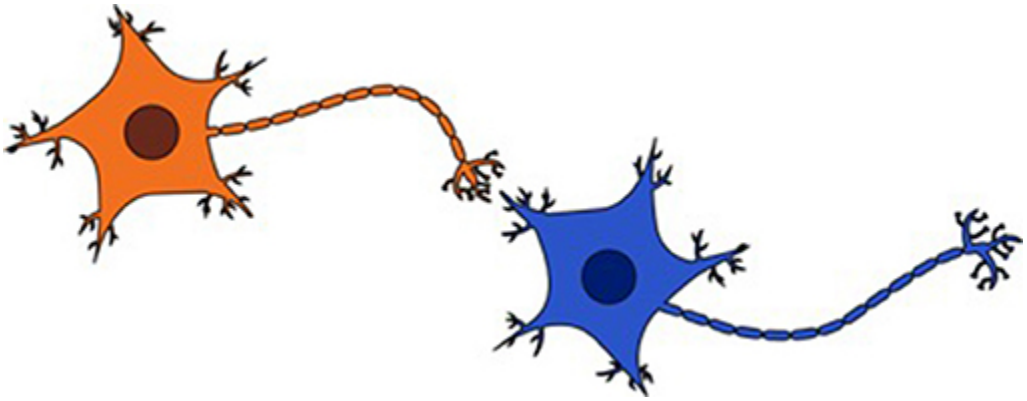


Figure 2.1 illustrates two neurons that are connected.

Each neuron can be connected with up to 10,000 other neurons, leading to a large number of connections in your brain which looks like a very dense spider web.[2],

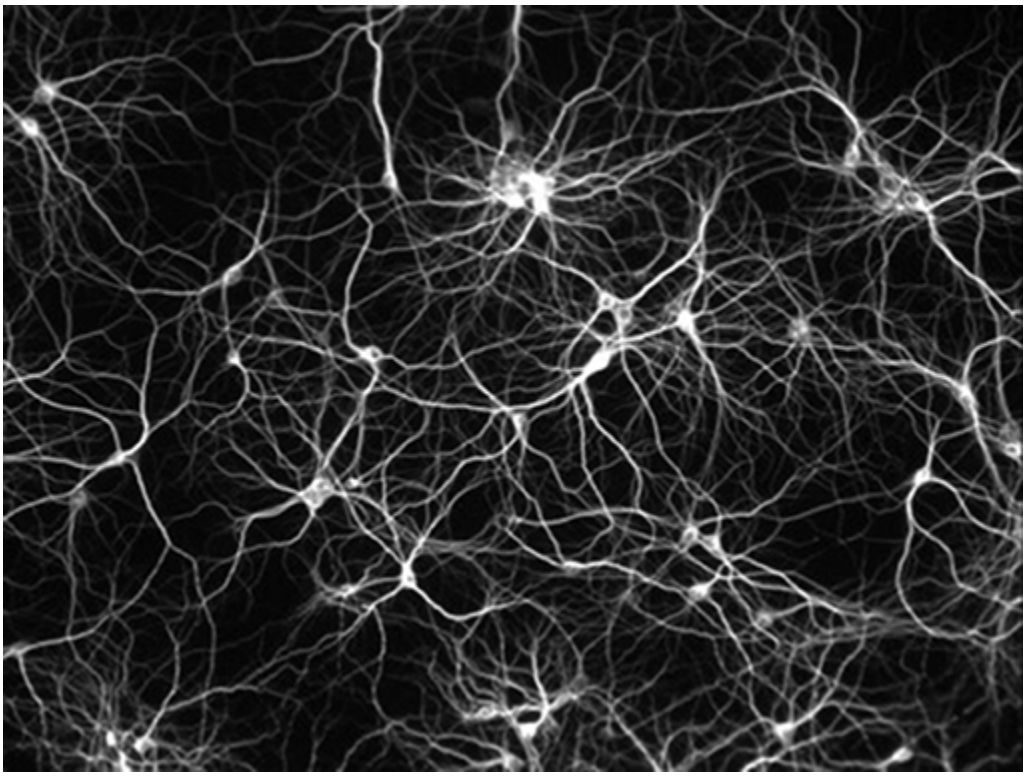


Figure 2.2 An image of a neural network (a group of neurons with multiple interconnected synapses)

2. Rossi, S., Lanoë, C., Poirel, N., Pineau, A., Houdé, O., and Lubin, A. 2015. When I met my brain: Participating in a neuroimaging study influences children's naive mind-brain conceptions. Trends Neurosci. Educ. 4:92–7. doi: 10.1016/j.tine.2015.07.001

Neuroplasticity

From a biological perspective, learning involves making new connections among neurons, altering existing ones (strengthening or weakening), and deleting unnecessary ones. The brain's ability to learn in this manner is called neuroplasticity. Neuroplasticity is "the capacity of the nervous system to modify its organization" (Sagi et al., 2012). With neuroplasticity, connections among brain cells are constantly being made, altered, and removed throughout our lives. From our understanding of neuroplasticity, we know that learning is an observable biological process. If we could peer inside a brain, we could see it happening – within the brain (among its neurons) connections are being made – structural and functional changes in the brain are taking place. Learning involves changing the brain. This continues until the day we die. The fact that learning rewires your neurons shows how dynamic (plastic) your brain is – that the brain changes and does not remain fixed[3].

How to Change Your Brain and Become a Better Learner

How can you change your brain and become a more effective learner? Practice! The more you practice, the stronger these connections become. As your connections strengthen, the messages (nerve impulses) are transmitted increasingly faster, making them more efficient[4]. That is how you become better at anything you learn, whether it is playing football, reading, drawing, doing mathematics, etc. We can compare the connections between your neurons to trails in a forest (see Figure 2.3 below). To illustrate, think about hiking in the forest. Initially, walking through a forest without a trail is difficult because you have to compact and push the vegetation and branches out of the way to carve your way through. But the more you use the same trail, the easier and more passable it becomes. Conversely, when you stop using the trail, the vegetation grows back, and the trail slowly disappears.

3. Sagi, Y., Tavor, I., Hofstetter, S., Tzur-Moryosef, S., Blumenfeld-Katzir, T., & Assaf, Y. (2012). Learning in the fast lane: new insights into neuroplasticity. Neuron, 73, (6), 1195-1203.

4. Kania, B. F., Wronska, D., and Zieba, D. 2017. Introduction to neural plasticity mechanisms. J. Behav. Brain Sci. 7:41–8. doi: 10.4236/jbbs.2017.72005

Figure 2.3

This analogy can help you visualize what happens in your brain when you are learning something for the first time. At first, learning is difficult. You don't understand it. You get frustrated. You haven't built the neural connections yet, but if you keep trying, you will eventually build an interconnected neural network, and it gets easier, and you understand it better because the connections are stronger and faster. Conversely, when you stop practicing something, the connections between your neurons weaken and can ultimately be dismantled or pruned. That is why it may seem difficult to play a musical instrument (or remember a poem you memorized a long time ago) after not practicing for a long time. However, it is also possible for some neural networks to become so strong that the trails or connections never completely disappear.

Neuroplasticity is the ability of your brain to change, that is to create, strengthen, weaken or dismantle connections between your neurons throughout life.

Tips to Help you Rewire your Brain

Practicing or rehearsing repeatedly activates your neurons and makes you learn. These changes happen as early as when a baby is in their mother's womb and continues throughout a person's life. So, the question is, how can you help your neurons create and strengthen their connections? Here, we present two strategies that appear to be more compatible with how your brain works and could help you learn better.

Strategy 1: Repeatedly Activating Your Neurons

Practicing a lot, trying to retrieve information from your memory (i.e. thinking) for example by explaining a concept to a friend or answering quiz questions.

Because the connections between your neurons need to be activated multiple times to become stronger and more efficient, a first and crucial strategy is to repeatedly activate them. This means that to learn arithmetic tables for instance, you have to practice it repeatedly, to establish the "trail" between your neurons. As a baby, you were not able to speak and walk within 1 day: you practiced a lot. However, it is important to note that only reading or glancing at your arithmetic tables will not be that helpful in connecting your neurons. You might also find it quite disengaging and boring. To create the connections between your neurons, you need to actively retrieve the arithmetic tables from your memory, and it can be really hard work at times. In other words, you have to try to recall the answer yourself to activate your connections. We are not saying that this is easy to do! However, scientists think that this "struggle" improves learning because the challenge is an indication that you are building new connections. Remember, learning something new is like hiking in a forest with no designated trail; you will probably walk slowly at first, but if you keep hiking, trails will start forming and eventually you will be walking on well-beaten tracks. Besides, when you do try to recall what you have learned and make a mistake, it can help you identify gaps in your learning and give you an indication of which trail still needs to be worked on.

Scientists have also noted that performing tests or exams can help you remember information better than studying alone[5]. For example, if you study your arithmetic tables interspersed with test periods, you will probably perform better on your final test than if you had only studied. Why? The tests require that you retrieve the information from the neurons in which the information is stored, thus activating your connections and contributing to their strengthening. The point is thus to practice retrieval in an engaging way. There are different strategies can try. For example answering practice questions or using flashcards. These should improve learning more than re-reading or listening to lectures (as long as you do not flip the flashcard over before recalling the answer!). Other strategies include preparing questions to ask to a classmate or a parent as well as redoing tests or exercises. Use your imagination! What you need to remember is that first, for your neurons to strengthen their connections, you need to retrieve the information and avoid just reading or listening to

5. Zaromb, F. M., and Roediger, H. L. 2010. The testing effect in free recall is associated with enhanced organizational processes. Mem. Cogn. 38:995–1008. doi: 10.3758/MC.38.8.995

the answer. Second, you should plan a way to get feedback to know whether you got something correct or incorrect. Do not be discouraged if you face challenges, this is a natural step of the learning process taking place in your brain!

Strategy 2: Spacing the Activation of Neurons

Practicing more often but for a shorter period. For example, instead of studying for 2 hours in a row, studying 4 periods of 30 min over a few days allows your brain to take breaks and sleep which helps you remember better in the long run.

Now that you know that neurons need to be activated repeatedly for learning to occur (and that it means retrieving information), you probably wonder how often you should practice. Scientists who study the learning brain observed that breaks and sleep between learning periods enhance learning and minimize forgetting[6]. It therefore seems better to retrieve often within spaced practice sessions, as opposed to a massed practice (practicing a task continuously without rest). For instance, instead of studying or doing homework for 3 h, after which you would probably feel exhausted anyway, you could separate this learning period into three 1-h periods or even into six half-an-hour periods. In short, when spacing your retrieval practice, you allow your brain to make the connections that you strengthened during your practice sessions more efficient. When you take a quick break from practicing, let us say a 20 min recess, you allow for the maintenance or replacement of the receptors on the surface of the neurons. The receptors are like electric outlets that receive the nerve impulse (electrical signals) from other neurons. Taking a break helps them work better: your neurons can thus transmit their nerve impulses more easily to other neurons. Finally, when you get a full night of sleep between practice sessions, you actually benefit from a free retrieval practice session because while you sleep, your brain reactivates the connections between the neurons (in a process called memory consolidation) that you activated during the day. You could also get similar benefits from a nap. Next time you find yourself sleepy in class, you could tell your teacher that you are in fact trying to do retrieval practice! In brief, when spacing out learning, and especially retrieval practice, your brain is more activated than when you mass learn in one long session.

At this point, you are probably asking yourself how to space out learning in your day-to-day life. The good news is that there are a number of ways to do it and it can be easily adapted to different skills, such as solving

6. Callan, D. E., and Schweighofer, N. 2010. Neural correlates of the spacing effect in explicit verbal semantic encoding support the deficient-processing theory. Hum. Brain Mapp. 31:645–59. doi: 10.1002/hbm.20894

mathematical problems or memorizing definitions. The most obvious change you can make to your study schedule is to break up sessions into smaller sessions. You could also ask your teacher to set daily or weekly review quizzes and other assignments. Finally, spacing can be done by doing interleaved practice. This consists of working on different but similar types of problems. For example, in math class, instead of doing repeated practice sessions of a single math skill, such as addition, students could work on adding *and* subtracting numbers in random sequences. Another example, instead of studying photosynthesis for a long period of time, students could interleave studying photosynthesis and cellular respiration during that same block of time. The added benefit of interleaving is that you engage in different activities in-between two sessions, making good use of your time. In brief, one thing to keep in mind is that information that was previously learned will require less effort to re-learn because the spacing gives your brain time to consolidate—meaning your brain produces the building blocks required for the connections between your neurons.

Conclusion

Your brain is where learning occurs and you therefore need to keep your neurons active to optimize the use of class or study time. The two learning strategies proposed in this article have the potential to help you learn better by creating optimal conditions to strengthen and consolidate the connections between your neurons. You now know that you can get better by repeatedly using the "trails" in your brain and by spacing out your practice. This greater understanding of how your brain learns and the use of supportive learning strategies can now allow you to help your brain learn better!

Watch It

Halo Sports– This commercial for Halo Sports illustrates the process of learning by practicing shooting free throws.

Links to Learning

1. Build a Neural Network Activity

2. Active Learning: Engaging People in the Learning Process
3. Teaching as Brain Changing: Exploring Connections between Neuroscience and Innovative Teaching

Review & Practice

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://uark.pressbooks.pub/edlearningtheory/?p=91#h5p-3

Critical Thinking

1. Based on what you have read and learned in this section, write out a definition of learning from a biological perspective in your own words.
2. Come up with your own model (or analogy) to illustrate what happens in the brain when you learn something new.
3. Distinguish between the terms learning and neural pathway building.
4. What role does motivation play in the learning process?

Glossary

Neuroplasticity: The ability of your brain to change, that is to create, strengthen, weaken or dismantle connections between your neurons.

Repeatedly Activating Your Neurons: Practicing a lot, trying to retrieve information from your memory, for example by explaining a concept to a friend or answering quiz questions.

Spacing the Activation of Neurons: Practicing more often but for a shorter period. For example, instead of studying for 2 h in a row, studying 4 periods of 30 min over a few days allows your brain to take breaks and sleep which helps you remember better in the long run.

This chapter is adapted from Blanchette Sarrasin, J., Brault Foisy, L.M., Allaire-Duquette, G. & Masson, S. (2020). Understanding Your Brain to Help You Learn Better. Front. *Young Minds.* 8:54. doi: 10.3389/frym.2020.00054

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Media Attributions

- image6

CHAPTER 3: BRAIN GROWTH AND DEVELOPMENT

Brain Growth and Development

Learning Objectives

- Explain the processes and function of synaptic blooming and synaptic pruning.
- Explain the concept of neural plasticity and its implications for the lifespan.
- Identify three major brain developments in adolescence.

The Brain in The First Two Years

Some of the most dramatic physical change that occurs during this period is in the brain. At birth, the brain is about 25 percent of its adult weight, and this is not true for any other part of the body. By age 2, it is at 75 percent of its adult weight, at 95 percent by age 6, and at 100 percent by age 7 years.

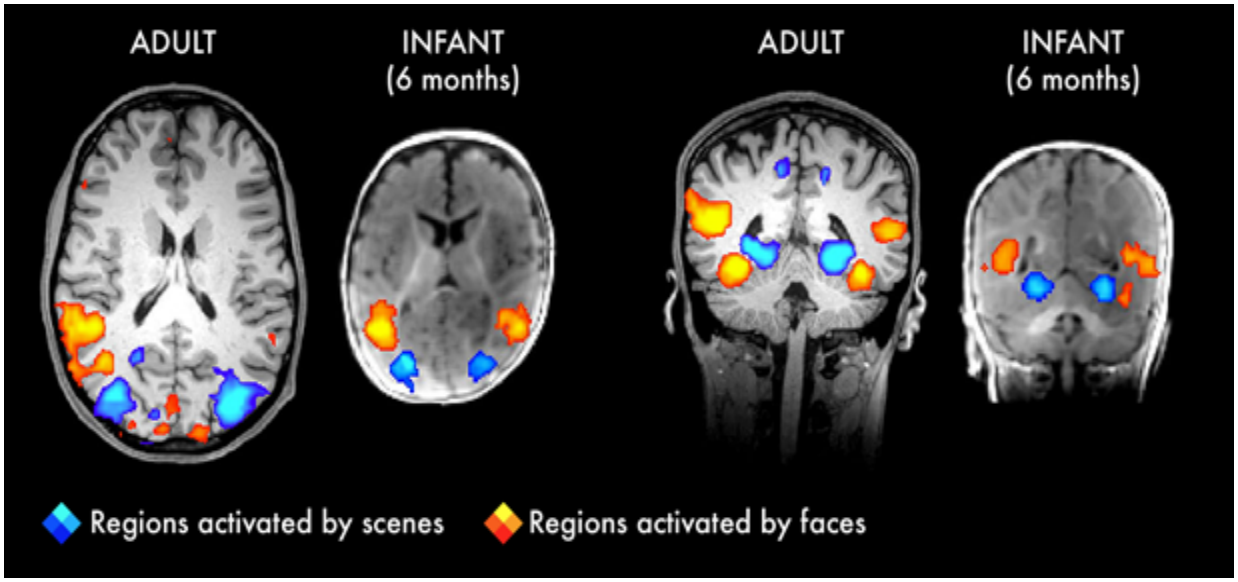

Figure 3.1 Research shows that as early as 4-6 months, infants utilize similar areas of the brain as adults to process information

We are born with most of the brain cells that we will ever have; that is, about 85 billion neurons whose function is to store and transmit information (Huttenlocher & Dabholkar, 1997). While most of the brain's neurons are present at birth, they are not fully mature. During the next several years dendrites, *or branching extensions that collect information from other neurons* , will undergo a period of transient exuberance or temporary dramatic growth (*exuberant* because it is so rapid and transient because some of it is temporary). Because of this proliferation of dendrites, by age two a single neuron might have thousands of dendrites. Synaptogenesis, *or the formation of connections between neurons*, continues from the prenatal period forming thousands of new connections during infancy and toddlerhood. *This period of rapid neural growth is referred to as* **synaptic blooming.**

The blooming period of neural growth is then followed by a period of **synaptic pruning**, *where neural connections are reduced thereby making those that are used much stronger* . It is thought that pruning causes the brain to function more efficiently, allowing for mastery of more complex skills (Kolb & Whishaw, 2011). Experience will shape which of these connections are maintained and which of these are lost. Ultimately, about 40 percent of these connections will be lost (Webb et al., 2001). Blooming occurs during the first few years of life, and pruning continues through childhood and into adolescence in various areas of the brain.

Another major change occurring in the central nervous system is the development of myelin, *a coating of fatty tissues around the axon of the neuron* (Carlson, 2014). Myelin helps insulate the nerve cell and speed the rate of transmission of impulses from one cell to another. This enhances the building of neural pathways and improves coordination and control of movement and thought processes. The development of myelin continues into adolescence but is most dramatic during the first several years of life. This myelination process also occurs in response to active use (activity-dependent myelination).

The infant brain grows very fast. At birth the brain is about 250 grams (half a pound) and by one year it is

already 750 grams (Eliot, 1999). Compared to adult size, the newborn brain is approximately 33% of adult size at birth, and in just 90 days, it is already at 55% of adult size (Holland et al., 2014). Most of the neural activity is occurring in the cortex *or the thin outer covering of the brain involved in voluntary activity and thinking*. The cortex is divided into two hemispheres, and each hemisphere is divided into four lobes, each separated by folds known as fissures. If we look at the cortex starting at the front of the brain and moving over the top, we see first the frontal lobe (behind the forehead), which *is responsible primarily for thinking, planning, memory, and judgment*. Following the frontal lobe is the parietal lobe, *which extends from the middle to the back of the skull and which is responsible primarily for processing information about touch*. Next is the occipital lobe, at the very back of the skull, which processes visual information. Finally, in front of the occipital lobe, between the ears, is the temporal lobe, which is *responsible for hearing and language* (Jarrett, 2015).

Watch it

How Baby Brains Develop

Although the brain grows rapidly during infancy, specific brain regions do not mature at the same rate. Primary motor areas develop earlier than primary sensory areas, and the prefrontal cortex, that is located behind the forehead, is the least developed (Giedd, 2015). As the prefrontal cortex matures, the child is increasingly able to regulate or control emotions, to plan activities, strategize, and have better judgment. This is not fully accomplished in infancy and toddlerhood, but continues throughout childhood, adolescence and into adulthood.

Lateralization *is the process in which different functions become localized primarily on one side of the brain*. For example, in most adults the left hemisphere is more active than the right during language production, while the reverse pattern is observed during tasks involving visuospatial abilities (Springer & Deutsch, 1993). This process develops over time, however, structural asymmetries between the hemispheres have been reported even in fetuses (Chi et al., 1997; Kasprian et al., 2011) and infants (Dubois et al., 2009).

Lastly, neuroplasticity *refers to the brain's ability to change, both physically and chemically, to enhance its adaptability to environmental change and compensate for injury*. The control of some specific bodily functions, such as movement, vision, and hearing, is performed in specified areas of the cortex, and if these areas are damaged, the individual will likely lose the ability to perform the corresponding function. The brain's neurons have a remarkable capacity to reorganize and extend themselves to carry out these particular functions in response to the needs of the organism, and to repair any damage. As a result, the brain constantly creates new neural communication routes and rewires existing ones. Both environmental experiences, such as stimulation and events within a person's body, such as hormones and genes, affect the brain's plasticity. So too does age.

Adult brains demonstrate neuroplasticity, but they are influenced less extensively than those of infants (Kolb & Fantie, 1989; Kolb & Whishaw, 2011).

Watch it

Infant Looking Time Habituation – What Babies Can Do

Babies are Surprisingly Smart- Even before they can walk or talk, they are learning all sorts of cognitive tasks.

The Adolescent Brain

The brain undergoes dramatic changes during adolescence. Although it does not get larger, it matures by becoming more interconnected and specialized (Giedd, 2015). The myelination and development of connections between neurons continues. This results in an increase in the white matter of the brain that allows the adolescent to make significant improvements in their thinking and processing skills. Different brain areas become myelinated at different times. For example, the brain's language areas undergo myelination during the first 13 years. Completed insulation of the axons consolidates these language skills but makes it more difficult to learn a second language. With greater myelination, however, comes diminished plasticity as a myelin coating inhibits the growth of new connections (Dobbs, 2012).

Even as the connections between neurons are strengthened, synaptic pruning occurs more than during childhood as the brain adapts to changes in the environment. This synaptic pruning causes the gray matter of the brain, or the cortex, to become thinner but more efficient (Dobbs, 2012). The corpus callosum, which connects the two hemispheres, continues to thicken allowing for stronger connections between brain areas. Additionally, the hippocampus becomes more strongly connected to the frontal lobes, allowing for greater integration of memory and experiences into our decision making.

The Teen Brain: 6 Things to Know

As you learn about brain development during adolescence, consider these six facts from National Institute of Mental Health

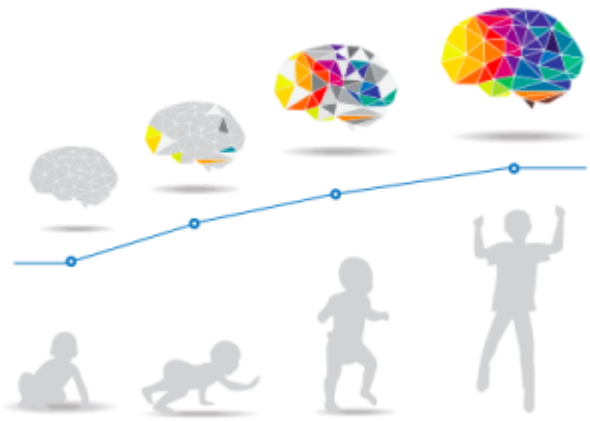

Figure 3.2 The brain reaches its largest size in the early teen years but continues to mature well into the 20s

Your brain does not keep getting bigger as you get older

For girls, the brain reaches its largest physical size around 11 years old; for boys, it reaches its largest physical size around age 14. Of course, this difference in age does not mean either boys or girls are smarter than one another!

But that doesn't mean your brain is done developing and maturing

For both boys and girls, although your brain may be as large as it will ever be, your brain doesn't finish developing and maturing until your mid- to late-20s. The front part of the brain, called the prefrontal cortex, is one of the last brain regions to mature. It is the area responsible for planning, prioritizing and controlling impulses.

The teen brain is ready to learn and adapt

In a digital world that is constantly changing, the adolescent brain is well prepared to adapt to new technology—and is shaped in return by experience.

Many mental disorders appear during adolescence

All the big changes the brain is experiencing may explain why adolescence is the time when many mental disorders—such as schizophrenia, anxiety, depression, bipolar disorder, and eating disorders—emerge.

The teen brain is resilient

Although adolescence is a vulnerable time for the brain and for teenagers in general, most teens go on to

become healthy adults. Some changes in the brain during this important phase of development may actually help protect against long-term mental disorders.

Teens need more sleep than children and adults

Although it may seem like teens are lazy, science shows that melatonin levels (or the "sleep hormone" levels) in the blood naturally rise later at night and fall later in the morning than in most children and adults. This may explain why many teens stay up late and struggle with getting up in the morning. Teens should get about 9-10 hours of sleep a night, but most teens don't get enough sleep. A lack of sleep makes paying attention hard, increases impulsivity and may also increase irritability and depression.

The limbic system, which regulates emotion and reward, is linked to the hormonal changes that occur at puberty. The limbic system is also related to novelty seeking and a shift toward interacting with peers. In contrast, the prefrontal cortex which is involved in the control of impulses, organization, planning, and making good decisions, does not fully develop until the mid-20s. According to Giedd (2015), an important outcome of the early development of the limbic system combined with the later development of the prefrontal cortex is the "mismatch" in timing between the two. The approximately ten years that separate the development of these two brain areas can result in increases in risky behavior, poor decision making, and weak emotional control for the adolescent. When puberty begins earlier, this mismatch lasts even longer.

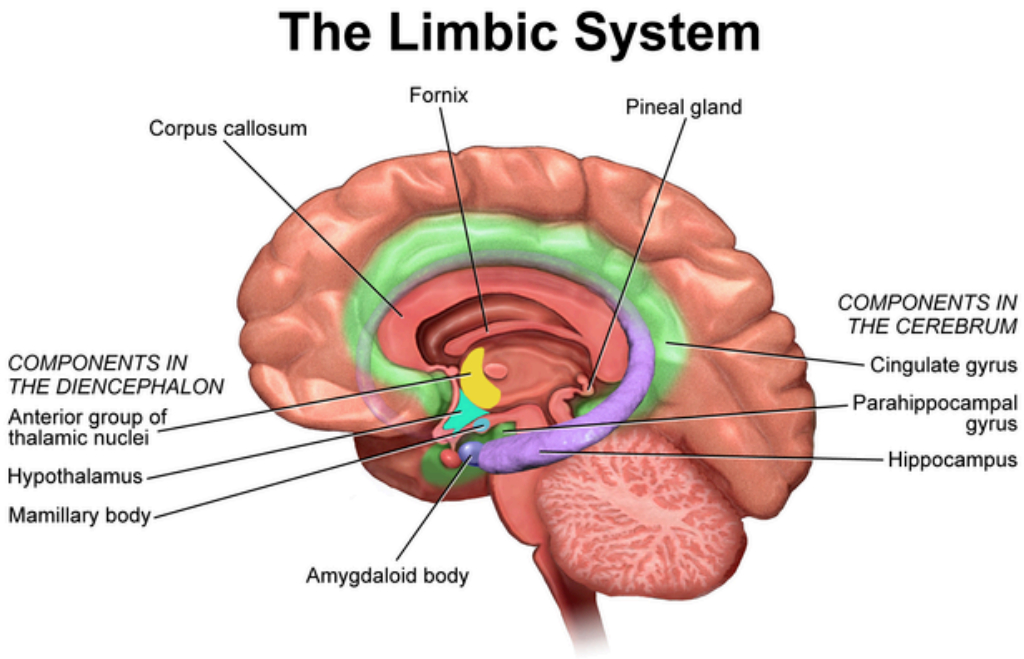

Figure 3.3 Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010. ISSN 2002-4436

Teens typically take more risks than adults and according to research it is because they weigh risks and rewards differently than adults do (Dobbs, 2012). The brain's sensitivity to the neurotransmitter dopamine peaks during adolescence, and dopamine is involved in reward circuits, so adolescents may judge that the possible

rewards outweigh the risks. Adolescents respond especially strongly to social rewards during activities, and they prefer the company of others their same age. Chein et al. (2011) found that peers sensitize brain regions associated with potential rewards. For example, adolescent drivers make more risky driving decisions when with friends to impress them, and teens are much more likely to commit crimes together in comparison to adults (30 and older) who commit them alone (Steinberg et al., 2018). In addition to dopamine, the adolescent brain is affected by oxytocin
which facilitates bonding and makes social connections more rewarding . With both dopamine and oxytocin engaged, it is no wonder that adolescents seek peers and excitement in their lives that could actually end up endangering them.

Watch it

How Teenagers' Brain are Wired Differently

The Mysterious Workings of the Adolescent Brain

Because of all the changes that occur in the brain during adolescence, the chances for abnormal development, including the emergence of mental illness, also rise. In fact, 50% of all mental illnesses occur by the age of 14, and 75% occur by age 24 (Giedd, 2015). Additionally, during this period of development, the adolescent brain is especially vulnerable to damage from drug exposure. For example, repeated exposure to marijuana can affect cellular activity in the endocannabinoid system. Consequently, adolescents are more sensitive to the effects of repeated marijuana exposure (Weir, 2015).

However, researchers have also focused on the highly adaptive qualities of the adolescent brain, which allow the adolescent to move away from the family and toward the outside world (Dobbs, 2012; Giedd, 2015). Novelty-seeking and risk-taking can generate positive outcomes, including meeting new people and seeking new situations. Separating from the family and moving into new relationships and different experiences are quite adaptive– for adolescents and society.

Links to Learning

Social cognitive development during adolescence. Suparna Choudhury, Sarah-Jayne Blakemore, Tony Charman Social Cognitive and Affective Neuroscience, Volume 1, Issue 3, December 2006, Pages 165–174, https://doi.org/10.1093/scan/nsl024

Watch it

Brain changes during adolescence | Behavior | MCAT | Khan Academy – his video further explains and highlights some of the key developments in the brain during adolescence. You can view the transcript for the video.

Key Takeaways

In sum, the adolescent years are a time of intense brain changes. Interestingly, two of the primary brain functions develop at different rates. Brain research indicates that the part of the brain that perceives rewards from risk, the limbic system, kicks into high gear in early adolescence. The part of the brain that controls impulses and engages in longer-term perspective, the frontal lobes, matures later. This may explain why teens in mid-adolescence take more risks than older teens. As the frontal lobes become more developed, two things happen. First, self-control develops as teens are

better able to assess cause and effect. Second, more areas of the brain become involved in processing emotions, and teens become better at accurately interpreting others' emotions[1].

The Brain in Late Adulthood

Research has demonstrated that the brain loses 5% to 10% of its weight between 20 and 90 years of age (Fjell & Walhovd, 2010). This decrease in brain volume appears to be due to the shrinkage of neurons, decreases in the number of synapses, and increasingly shorter axon lengths. According to Garrett (2015), normal declines in cognitive ability throughout the lifespan are associated with brain changes, including reduced activity of genes involved in memory storage, synaptic pruning, plasticity, and glutamate and GABA (neurotransmitters) receptors.

There is also a loss in white matter connections between brain areas. Without myelin, neurons demonstrate slower conduction and impede each other's actions. A loss of synapses occurs in specific brain areas, including the hippocampus (involved in memory) and the basal forebrain region. Older individuals also activate larger regions of their attentional and executive networks, located in the parietal and prefrontal cortex, when they perform complex tasks. This increased activation coincides with reduced performance on both executive tasks and tests of working memory when compared to that of younger people (Kolb & Whishaw, 2011).

Review & Practice

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://uark.pressbooks.pub/edlearningtheory/?p=99#h5p-4

1. https://openbooks.library.baylor.edu/lifespanhumandevelopment/chapter/chapter-8-1-brain-development/#footnote-755-1

Critical Thinking

1. How are you different today from the person you were at 6 years old? What about at 16 years old? How are you the same as the person you were at those ages?

PART II

UNIT TWO: LEARNING DEVELOPMENT

CHAPTER 4: COGNITIVE DEVELOPMENT (JEAN PIAGET)

Learning Objectives

- Describe learning in terms of schema development via assimilation and accommodation.
- Describe Piaget's 4 Stages of Development and the key learning accomplishments in each stage.

Schema Development

Jean Piaget (1896–1980) is a stage theorist who studied childhood development. He focused on children's cognitive growth and development. He believed that thinking is a central aspect of development and that children are naturally inquisitive. However, he said that children do not think and reason like adults (Piaget, 1930, 1932).

Figure 4.1 Jean Piaget spent over 50 years studying children and how their minds develop

Piaget said that children develop **schemata** to help them understand the world. **Schemata** are concepts (mental models) that are used to help us categorize and interpret information. By the time children have reached adulthood, they have created schemata for almost everything. When children learn new information, they adjust their schemata through two processes: assimilation and accommodation. First, they assimilate new information or experiences in terms of their current schemata: **Assimilation** is when they take in information that is comparable to what they already know. **Accommodation** describes when they change their schemata based on new information. This process continues as children interact with their environment.

For example, 2-year-old Blake learned the schema for dogs because his family has a Labrador retriever. When Blake sees other dogs in his picture books, he says, "Look, Mommy, dog!" Thus, he has *assimilated* them into his schema for dogs. One day, Blake sees a sheep for the first time and says, "Look, Mommy, dog!" Having a basic schema that a dog is an animal with four legs and fur, Blake thinks all furry, four-legged creatures are dogs. When Blake's mom tells him that the animal he sees is a sheep, not a dog, Blake must *accommodate* his schema for dogs to include more information based on his new experiences. Blake's schema for dog was too broad since not all furry, four-legged creatures are dogs. Now, he modifies his schema for dogs and forms a new one for sheep.

Watch It

Illustration of Schema, Assimilation, and Accommodation– View this brief video to develop your understanding of schema, assimilation, and accommodation.

Our Knowledge System

Stages of Cognitive Development

Piaget also thought children's cognitive development unfolds in a series of stages approximately associated with age ranges. Piaget's stages theory exemplifies the **discontinuity** approach to development, which means as we progress to a new stage, there is a distinct shift in thinking and reasoning (as opposed to gradual changes happening over time). He proposed a theory of cognitive development that unfolds in four stages: sensorimotor, preoperational, concrete operational, and formal operational (see Table 1).

Table 1 Piaget's Stages of Cognitive Development

Age (years)	Stage	Description	Developmental issues
0–2	Sensorimotor	World experienced through senses and actions	Object permanence Stranger anxiety
2–6	Preoperational	Use words and images to represent things but lack logical reasoning	Pretend play Egocentrism Language development
7–11	Concrete operational	Understand concrete events and analogies logically; perform arithmetic operations	Conservation Mathematical transformations
12–	Formal operational	Formal operations Utilize abstract reasoning	Abstract logic Moral reasoning

The first stage is the **sensorimotor** stage, which lasts from birth to about 2 years old. Children learn about the world through their senses and motor behavior during this stage. Young children put objects in their mouths

to see if the items are edible, and once they can grasp objects, they may shake or bang them to see if they make sounds. Between 5 and 8 months old, the child develops **object permanence**, which is the understanding that even if something is out of sight, it still exists (Bogartz, Shinskey, & Schilling, 2000). According to Piaget, young infants do not remember an object after it has been removed from sight. Piaget studied infants' reactions when a toy was first shown to an infant and then hidden under a blanket. Infants who had already developed object permanence would reach for the hidden toy, indicating that they knew it still existed. In contrast, infants who had not developed object permanence would appear confused.

Watch It

Piaget – Stage 1 – Sensorimotor stage: Object Permanence -View this brief video demonstrating different children's ability to understand object permanence.

In Piaget's view, around the same time, as children develop object permanence, they also begin to exhibit **stranger anxiety**, which is a fear of unfamiliar people. Babies may demonstrate this by crying and turning away from a stranger, clinging to a caregiver, or attempting to reach their arms toward familiar faces such as parents. Stranger anxiety results when a child is unable to assimilate the stranger into an existing schema; therefore, she can't predict what her experience with that stranger will be like, which results in a fear response.

Piaget's second stage is the **preoperational stage,** which is approximately 2 to 7 years old. In this stage, children can use symbols to represent words, images, and ideas, which is why children in this stage engage in pretend play. A child's arms might become airplane wings as he zooms around the room, or a child with a stick might become a brave knight with a sword. Children also begin to use language in the preoperational stage. Still, they cannot understand adult logic or mentally manipulate information (the term operational refers to logical manipulation of information, so children at this stage are considered pre-operational). Children's logic is based on their own personal knowledge of the world so far, rather than on conventional knowledge. For example, Dad gave a slice of pizza to 10-year-old Keiko and another slice to her 3-year-old brother, Kenny. Kenny's pizza slice was cut into five pieces, so Kenny told his sister he got more pizza than she did. Children in this stage cannot perform mental operations because they have not developed an understanding of **conservation**, which is the idea that even if you change the appearance of something, it is still equal in size as long as nothing has been removed or added.

Watch It

A typical child on Piaget's conservation tasks– This video shows a 4.5-year-old boy in the preoperational stage as he responds to Piaget's conservation tasks.

During this stage, we also expect children to display **egocentrism**, which means that the child is not able to take the perspective of others. A child at this stage thinks that everyone sees, thinks, and feels just as they do. Let's look at Kenny and Keiko again. Keiko's birthday is coming up, so their mom takes Kenny to the toy store to choose a present for his sister. He selects an Iron Man action figure for her, thinking his sister will, too if he likes the toy. An egocentric child is not able to infer the perspective of other people and instead attributes his own perspective.

Piaget developed the **Three-Mountain Task** to determine the level of egocentrism displayed by children. Children view a 3-dimensional mountain scene from one viewpoint and are asked what another person at a different viewpoint would see in the same scene.

Watch It

Piaget's Mountain Task -Watch the Three-Mountain Task in action in this short video from the University of Minnesota and the Science Museum of Minnesota.

Piaget's third stage is the **concrete operational stage**, which occurs from about 7 to 11 years old. In this stage, children can think logically about real (concrete) events; they have a firm grasp on the use of numbers and start to employ memory strategies. They can perform mathematical operations and understand transformations, such as addition is the opposite of subtraction, and multiplication is the opposite of division. In this stage, children also master the concept of conservation: Even if something changes shape, its mass, volume, and number stay the same. For example, if you pour water from a tall, thin glass to a short, fat glass, you still have the same amount of water. Remember Keiko and Kenny and the pizza? How did Keiko know that Kenny was wrong when he said that he had more pizza?

Children in the concrete operational stage also understand the principle of **reversibility**, which means that objects can be changed and then returned back to their original form or condition. Take, for example, water

that you poured into the short, fat glass: You can pour water from the fat glass back to the thin glass and still have the same amount (minus a couple of drops).

The fourth, and last, stage in Piaget's theory is the **formal operational stage**, which is from about age 11 to adulthood. Whereas children in the concrete operational stage are able to think logically only about concrete events, children in the formal operational stage can also deal with abstract ideas and hypothetical situations. Children in this stage can use abstract thinking to problem solve, look at alternative solutions, and test these solutions. In adolescence, a **renewed egocentrism** occurs. For example, a 15-year-old with a very small pimple on her face might think it is huge and incredibly visible, under the mistaken impression that others must share her perceptions.

Review & Practice

1. Stages of Development (pdf)- Use this worksheet to review and practice identifying the 4 stages of cognitive development.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://uark.pressbooks.pub/edlearningtheory/?p=354#h5p-5

Critical Thinking

- What is the difference between assimilation and accommodation? Provide examples of each.
- Create or find a metaphor to illustrate your understanding of schemata.
- Based on what you read about Piaget's description of how children learn, what are some ways you can see his ideas influenced early childhood education?
- Based on your own experiences, can you take a critical perspective toward Piaget's 4

stages of cognitive development theory?

This chapter was remixed from Spielman, R.M., Jenkins, W.J., & Lovett, M.D. (2020). *Psychology 2e*. OpenStax. Access for free at https://openstax.org/books/psychology-2e/pages/9-2-lifespan-theories

CHAPTER 5: SOCIOCULTURAL THEORY (LEV VYGOTSKY)

Learning Objectives

1. Explain Vygotsky's sociocultural theory of cognitive development, including the role of the Zone of Proximal Development.
2. Compare and contrast Piaget's and Vygotsky's theories, focusing on their views of learning and development.
3. Analyze the teaching and learning implications of Piaget's and Vygotsky's theories, emphasizing scaffolding and the Zone of Proximal Development.

Modern social learning theories stem from the work of Russian psychologist Lev Vygotsky (see Figure 5.1), who produced his ideas as a reaction to existing conflicting approaches in psychology (Kozulin, 1990). Vygotsky's ideas are most recognized for identifying the role of social interactions and culture in the development of higher-order thinking skills. His theory is especially valuable for the insights it provides about the dynamic "interdependence between individual and social processes in the construction of knowledge" (John-Steiner & Mahn, 1996, p. 192). Vygotsky's ideas have many practical applications for learners of all ages.

Figure 5.1 Lev Vygotsky

Three themes are often identified with Vygotsky's ideas of sociocultural learning: (1) human development and learning originate in social, historical, and cultural interactions, (2) the use of psychological tools, particularly language, mediates the development of higher mental functions, and (3) learning occurs within the Zone of Proximal Development. While we discuss these ideas separately, they are closely interrelated.

Human Development and Learning Originate in Social, Historical, and Cultural Interactions

Vygotsky's sociocultural theory emphasizes the importance of culture and social interaction in the development of cognitive abilities. Vygotsky contended that thinking has social origins, social interactions play a critical role, especially in the development of higher-order thinking skills, and cognitive development cannot be fully understood without considering the social and historical context within which it is embedded. He explained, "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first between people (interpsychological) and then inside the child (intrapsychological)" (Vygotsky, 1978, p. 57). It is through working with others on a variety of tasks that a learner adopts socially shared experiences and associated effects and acquires useful strategies and knowledge (Scott & Palincsar, 2013).

Rogoff (1990) refers to this process as guided participation, where a learner actively acquires new culturally valuable skills and capabilities through a meaningful, collaborative activity with an assisting, more experienced other. It is critical to notice that these culturally mediated functions are viewed as being embedded in sociocultural activities rather than being self-contained. Development is a "transformation of participation in

a sociocultural activity," not a transmission of discrete cultural knowledge or skills (Matusov, 2015, p. 315). For example, young children learn problem-solving skills, not by sitting alone at a desk trying to solve arbitrary problems but by working alongside parents or older siblings as they work on actual culturally-relevant tasks, like preparing a family meal or repairing a fence. Working together, the dyad or group encounters social or physical problems and discusses their possible solutions before taking action. Through participation in joint problem-solving, young children develop these skills.

Language as a Developmental Tool

In his sociocultural view of development, Vygotsky highlighted the tools that the culture provides to support the development of higher order thought. Chief among them is language. For Vygotsky, children interact with the world through the tool of language. For Piaget, children use schemas that they construct and organize on the mental plane, but for Vygotsky, language, a social medium, was the mechanism through which we build knowledge of the world. He believed that with development, the language we acquire from our environment shapes the ways in which we think and behave. With development, language becomes internalized as thought (i.e., cognition, or reasoning) and children use this internalized language to guide their actions.

Zone of Proximal Development (and Scaffolding)

Vygotsky differed with Piaget in that he believed that a person not only has a set of actual abilities, but also a set of *potential* abilities that can be realized if given the proper guidance from others. He believed that through guided participation known as **scaffolding**, with a teacher or capable peer, a child can learn cognitive skills within a certain range known as the **zone of proximal development (ZPD)** . Have you ever taught a child to perform a task? Maybe it was brushing their teeth or preparing food. Chances are you spoke to them and described what you were doing while you demonstrated the skill and let them work along with you throughout the process. You gave them assistance when they seemed to need it, but once they knew what to do, you stood back and let them go. This is scaffolding. This approach to teaching has also been adopted by educators. Rather than assessing students on what they are doing, they should be understood in terms of what they are capable of doing with the proper guidance and mentoring. See Figure 5.2 below for a physical representation or a model of ZPD.

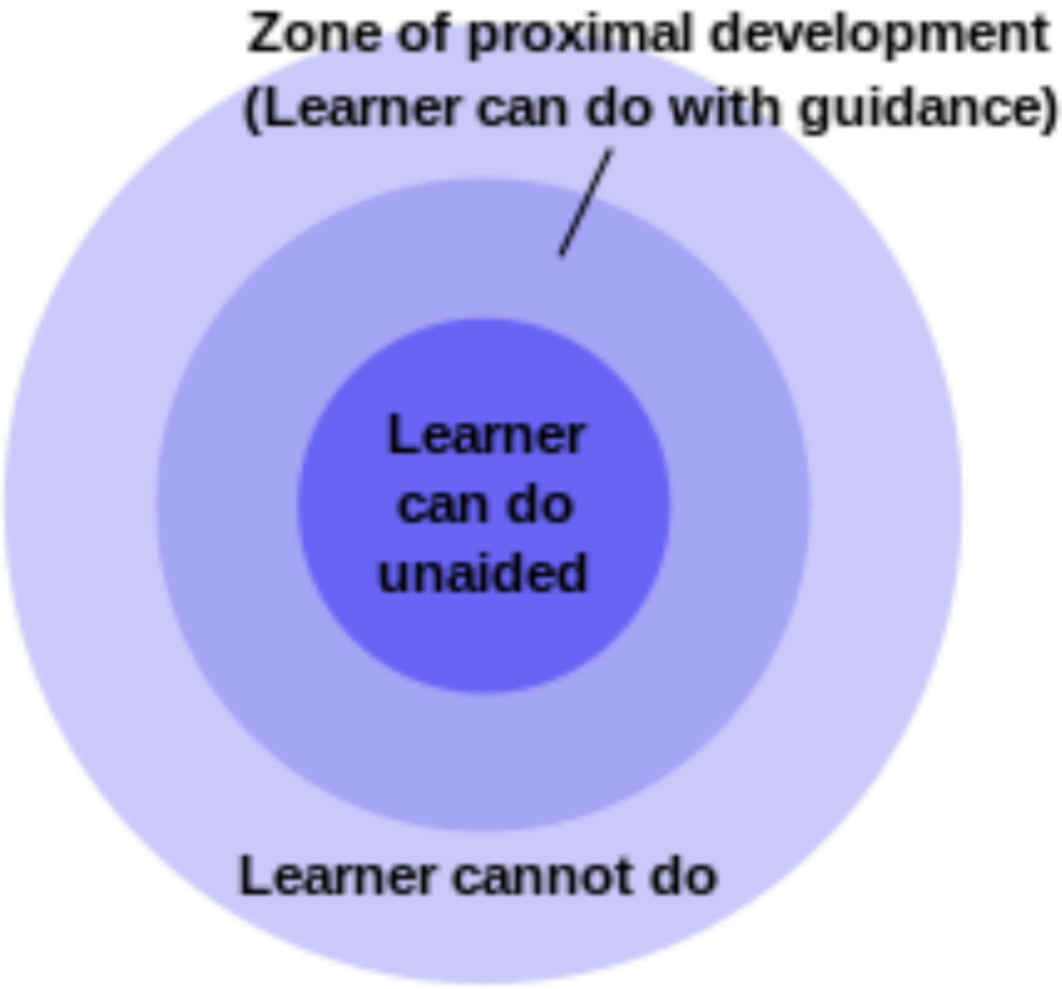

Figure 5.2 Vygotsky's zone of proximal development represents what a student can learn with the proper support

Watch It

Vygotsky's Zone of Proximal Development Explained (YouTube)

External Links to Learning

Six Scaffolding Strategies to Use With Your Students (Edutopia article)

Note: *Although Vygotsky himself never mentioned the term scaffolding, it is often credited to him as a continuation of his ideas pertaining to the way adults or other children can use guidance in order for a child to work within their ZPD. (The term scaffolding was first developed by Jerome Bruner, David Wood, and Gail Ross while applying Vygotsky's concept of ZPD to various educational contexts.)*

Vygotsky's theories do not just apply to language development but have been extremely influential for education in general. Educators often apply these concepts by assigning tasks that students cannot do on their own, but which they can do with assistance; they should provide just enough assistance so that students learn to complete the tasks independently and then provide an environment that enables students to do harder tasks than would otherwise be possible. Teachers can also allow students with more knowledge to assist students who need more guidance. Especially in the context of collaborative learning, group members who have higher levels of understanding can help the less advanced members learn within their zone of proximal development.

Piaget VS Vygotsky and Instructional Implications

While both Piaget and Vygotsky highlighted the importance of interactions with the social and physical world as the sources of developmental change, Piaget's ideas of cognitive development emphasize universal stages progressing toward increasing cognitive complexity. Vygotsky presents a more culturally-embedded view in which situated participatory learning drives development. The idea of learning driving development, rather than being determined by the developmental level of the learner, fundamentally changes our understanding of the learning process and has significant instructional and educational implications (Miller, 2011).

This difference in assumptions has significant implications for the design and development of learning experiences. If we believe as Piaget did that development precedes learning, then we will introduce children to learning activities involving new concepts and problems, but follow their lead, allowing learners to initiate participation when they are ready or interested. On the other hand, if we believe as Vygotsky did that learning drives development and that development occurs as we learn a variety of concepts and principles, recognizing their applicability to new tasks and new situations, then our instructional design will look very different.

Review & Practice

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://uark.pressbooks.pub/edlearningtheory/?p=405#h5p-6

Critical Thinking

- How can educators determine a student's ZPD for a given skill or concept?
- What are some sources of more expert others available in the classroom (besides the teacher)?
- In what ways does the ZPD relate to differentiated instruction in the classroom?
- How can teachers apply the ZPD when working with students of varying abilities in the same classroom?
- What are the consequences of consistently providing too much or too little support within a student's ZPD?

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CHAPTER 6: MORAL DEVELOPMENT THEORY (KOLBERG)

Learning Objectives

- Differentiate between Kohlberg's preconventional, conventional, and postconventional levels of moral development, providing examples of reasoning at each stage.
- Critically evaluate Kohlberg's theory of moral development in terms of sociocultural contexts.

A major task beginning in childhood and continuing into adolescence is discerning right from wrong. Psychologist Lawrence Kohlberg (1927–1987) extended upon the foundation that Piaget built regarding cognitive development. Kohlberg believed that moral development, like cognitive development, follows a series of stages. To develop this theory, Kohlberg posed moral dilemmas to youn males ages 10-16, and then he analyzed their answers to find evidence of their particular stage of moral development. Before reading about the stages, take a minute to consider how you would answer one of Kohlberg's best-known moral dilemmas, commonly known as the Heinz dilemma:

In Europe, a woman was near death from a special kind of cancer. There was one drug that the doctors thought might save her. It was a form of radium that a druggist in the same town had recently discovered. The drug was expensive to make, but the druggist was charging ten times what the drug cost him to make. He paid $200 for the radium and charged $2,000 for a small dose of the drug. The sick woman's husband, Heinz, went to everyone he knew to borrow the money, but he could only get together about $1,000, which is half of what it cost. He told the druggist that his wife was dying and asked him to sell it cheaper or let him pay later. But the druggist said: "No, I discovered the drug, and I'm going to make money from it." So Heinz got desperate and broke into the man's store to steal the drug for his wife. Should the husband have done that? (Kohlberg, 1969, p. 379)

How would you answer this dilemma? What explanation would you give to justify your thinking?

Kohlberg was not interested in his subjects' answers; instead, he was interested in the reasoning behind their answers. After presenting his subjects with this and various other moral dilemmas, Kohlberg reviewed their responses and placed them into three different levels of moral reasoning: Level 1: Pre-conventional, Level 2: Conventional, and Level 3: Post-conventional. Subsequently he subdivided each level into two different stages, for six total stages. (See figure 6.1). Each stage builds on the prior stage sequentially.

According to Kohlberg, an individual progresses from the capacity for pre-conventional morality (before age 9) to the capacity for conventional morality (early adolescence), and toward attaining post-conventional morality (once formal operational thought is attained), which only a few fully achieve. Kohlberg placed in the highest stage responses that reflected the reasoning that Heinz should steal the drug because his wife's life is more important than the pharmacist making money. The fundamental value of a human life overrides the pharmacist's greed.

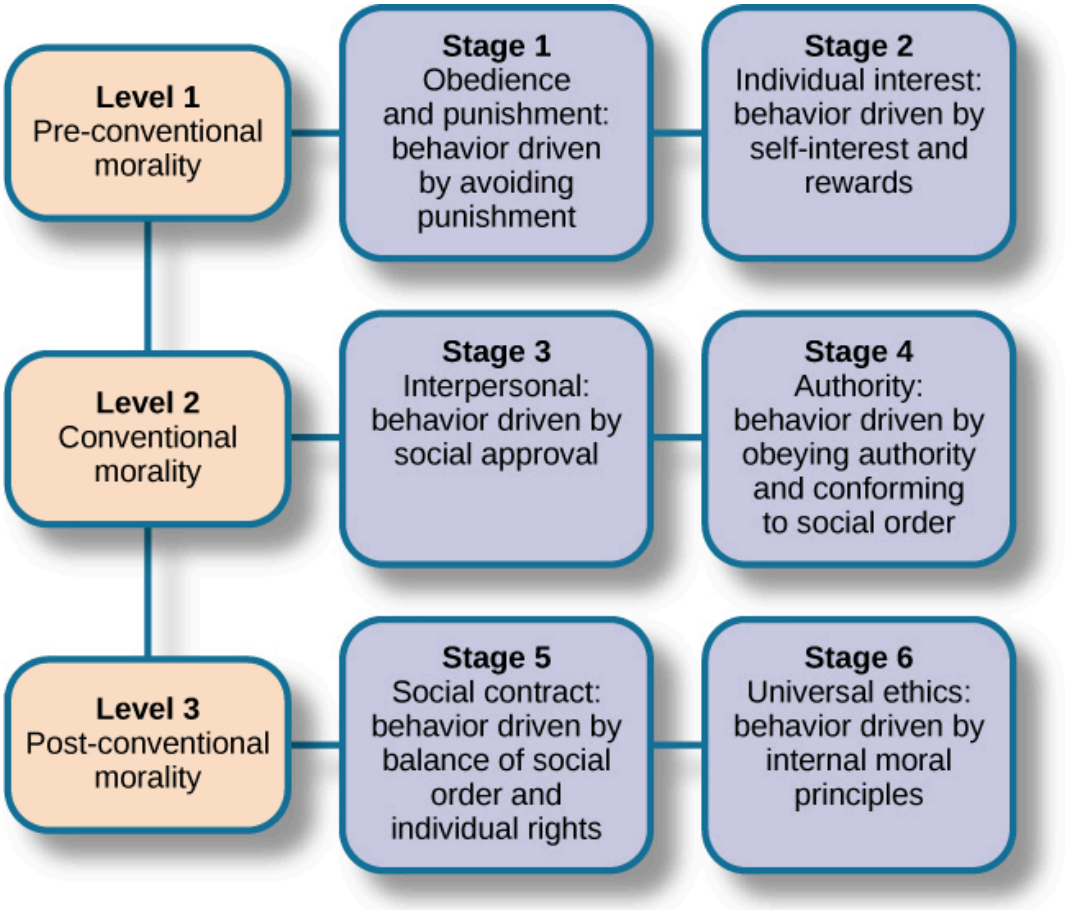

Figure 6.1 Kohlberg identified three levels of moral reasoning: pre-conventional, conventional, and post-conventional: Each level is associated with increasingly complex stages of moral development

External Links to Further Your Learning

- Kohlberg's Six Stages of Moral Development- Watch this Youtube video to help you understand the progression of how moral development occurs in the context of a fight in the school yard.
- Also read the corresponding explanation of Kohlbergs' Six Stages of Moral Development on the Sprouts website (Koblin, 2021).

Criticisms of Kohlberg's Moral Development Theory

Many psychologists agree with Kohlberg's theory of moral development but point out that moral reasoning differs greatly from moral behavior. Sometimes, what we say we would do in a situation is not what we actually do in that situation. In other words, we might "talk the talk" but not "walk the walk." Also, It is essential to realize that even people with the most sophisticated, post-conventional reasons for some choices may make other choices for the simplest of pre-conventional reasons.

How does this theory apply to males and females? Kohlberg (1969) felt that more males than females move past stage four in their moral development. He went on to note that women seem to be deficient in their moral reasoning abilities. These ideas were not well received by Carol Gilligan, a research assistant of Kohlberg, who consequently developed her own ideas of moral development. In her groundbreaking book, In a Different Voice: Psychological Theory and Women's Development, Gilligan (1982) criticized her former mentor's theory because it was based only on the male perspective. She argued that women are not deficient in their moral reasoning—she proposed that males and females reason differently. Girls and women focus more on staying connected and the importance of interpersonal relationships. She proposed that females demonstrate their moral development through an *ethic of care* rather than through the lens of human rights and social justice. Therefore, in the Heinz dilemma, many girls and women respond that Heinz should not steal the medicine. Their reasoning is that if he steals the medicine, is arrested, and is put in jail, then he and his wife will be separated, and she could die while he is still in prison.

Review & Practice

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https://uark.pressbooks.pub/edlearningtheory/?p=461#h5p-8

Critical Thinking

1. Based on your own experiences and perspectives, what are some potential limitations or criticisms of Kohlberg's Moral Development Theory?
2. Do you think individuals always progress through Kohlberg's stages in a linear fashion, or can they move back and forth between stages? Provide examples to support your answer.
3. Think of a moral decision you or someone you know has faced. Which of Kohlberg's stages best describes the reasoning behind that decision? Does it fully capture the complexity of the situation?

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CHAPTER 7: PSYCHOSOCIAL THEORY OF DEVELOPMENT (ERIKSON)

Psychosocial Theory of Development

Learning Objectives

- Identify and differentiate among Erikson's eight stages of psychosocial development, with an emphasis on the school years.
- Critically evaluate Erikson's Psychosocial Theory, including its strengths and limitations.
- Discuss implications of psychosocial development theory on teaching practices and student support.

Erik Erikson (1902–1994), another stage theorist, is well known for his influential psychosocial theory. Psychosocial development theory emphasizes the social nature of our development. Erikson suggested that how we interact with others is what affects our sense of self, or what he called the ego identity. He also proposed that personality development takes place all through the lifespan.

Figure 7.1 Erik Erikson proposed the psychosocial theory of development

Erikson proposed that we are motivated by a need to achieve competence in certain areas of our lives. According to psychosocial theory, we experience eight stages of development over our lifespan, from infancy through late adulthood. At each stage, there is a conflict or task that we need to resolve. Successful completion of each developmental task results in a sense of competence and a healthy personality. Failure to master these tasks leads to feelings of inadequacy.

According to Erikson (1963), trust is the basis of our development during infancy (birth to 12 months). Therefore, the primary task at this stage is to determine **trust versus mistrust**. Infants are dependent upon their caregivers, so caregivers who are responsive and sensitive to their infant's needs help their baby to develop a sense of trust; their baby will see the world as a safe, predictable place. Unresponsive caregivers who do not meet their baby's needs can engender feelings of anxiety, fear, and mistrust; their baby may see the world as unpredictable.

As toddlers (ages 1–3 years) begin exploring their world, they learn to control their actions and act on the environment to get results. They begin to show clear preferences for certain elements of the environment, such as food, toys, and clothing. A toddler's main task is to resolve the issue of **autonomy versus shame and doubt** by working to establish independence. This is the "me do it" stage. For example, we might observe a budding sense of autonomy in a 2-year-old child who wants to choose her clothes and dress herself. Although her outfits might not be appropriate for the situation, her input in such basic decisions affects her sense of independence. If denied the opportunity to act in her environment, she may begin to doubt her abilities, which could lead to low self-esteem and feelings of shame.

Once children reach the preschool stage (ages 3–6 years), they are capable of initiating activities and asserting control over their world through social interactions and play. According to Erikson, preschool children must

resolve the task of **initiative versus guilt.** By learning to plan and achieve goals while interacting with others, preschool children can master this task. Those who do will develop self-confidence and feel a sense of purpose. Those who are unsuccessful at this stage—with their initiative misfiring or stifled—may develop feelings of guilt. How might over-controlling parents stifle a child's initiative?

During the elementary school stage (ages 6–12), children face the task of **industry versus inferiority**. Children begin to compare themselves to their peers to see how they measure up. They either develop a sense of pride and accomplishment in their schoolwork, sports, social activities, and family life, or they feel inferior and inadequate when they don't measure up. What are some things parents and teachers can do to help children develop a sense of competence and a belief in themselves and their abilities?

In adolescence (ages 12–18), children face the task of **identity versus role confusion**. According to Erikson, an adolescent's main task is developing a sense of self. Adolescents struggle with questions such as "Who am I?" and "What do I want to do with my life?" Along the way, most adolescents try on many different selves to see which ones fit. Adolescents who are successful at this stage have a strong sense of identity and are able to remain true to their beliefs and values in the face of problems and other people's perspectives. What happens to apathetic adolescents who do not make a conscious search for identity or those who are pressured to conform to their parents' ideas for the future? These teens will have a weak sense of self and experience role confusion. They are unsure of their identity and confused about the future.

People in early adulthood (i.e., 20s through early 40s) are concerned with **intimacy versus isolation**. After we have developed a sense of self in adolescence, we are ready to share our life with others. Erikson said that we must have a strong sense of self before developing intimate relationships with others. Adults who do not develop a positive self-concept in adolescence may experience feelings of loneliness and emotional isolation.

When people reach their 40s, they enter the time known as middle adulthood, which extends to the mid-60s. The social task of middle adulthood is **generativity versus stagnation**. Generativity involves finding your life's work and contributing to the development of others, through activities such as volunteering, mentoring, and raising children. Those who do not master this task may experience stagnation, having little connection with others and little interest in productivity and self-improvement.

From the mid-60s to the end of life, we are in the period of development known as late adulthood. Erikson's task at this stage is called **integrity versus despair**. He said that people in late adulthood reflect on their lives and feel either a sense of satisfaction or a sense of failure. People who feel proud of their accomplishments feel a sense of integrity, and they can look back on their lives with few regrets. However, people who are not successful at this stage may feel as if their life has been wasted. They focus on what "would have," "should have," and "could have" been. They face the end of their lives with feelings of bitterness, depression, and despair. Table 1 below summarizes the stages of Erikson's theory.

Table 1 Erikson's Psychosocial Stages of Development

Stage	Age (years)	Developmental Task or	Description
1	0–1	Trust vs. mistrust	Trust that basic needs, such as nourishment and affection, will be met (or develop a mistrust of others)
2	1–3	Autonomy vs. shame/doubt	Develop a sense of independence in many tasks (or develop a sense of shame and doubt)
3	3–6	Initiative vs. guilt	Learn to take initiative on some activities (or develop guilt for trying)
4	7–11	Industry vs. inferiority	Develop self-confidence in abilities when competent (or a sense of inferiority when not)
5	12–18	Identity vs. confusion	Experiment with and develop identity and roles (or develop role and identity confusion)
6	19–29	Intimacy vs. isolation	Establish intimacy and relationships with others (or feel isolated)
7	30–64	Generativity vs. stagnation	Contribute to society and be part of a family (or lack a sense of purpose)
8	65–	Integrity vs. despair	Experience a sense of integrity and satisfaction (despair over a wasted life)

Criticism of Psychosocial Theory

Erikson's theory may be questioned as to whether his stages must be regarded as sequential and only occurring within the age ranges he suggests. There is debate as to whether people only search for identity during the adolescent years or if one stage needs to happen before other stages can be completed. Erikson himself states that each of these processes occurs throughout the lifetime in one form or another, and he emphasizes these periods only because it is at these times that the conflicts become most prominent (Erikson, 1956).

Educational Implications

Teachers who apply psychosocial development in the classroom create an environment where each child feels appreciated and is comfortable with learning new things and building relationships with peers.

At the preschool level, teachers want to focus on helping children develop healthy personalities and

- Find out what students are interested in and create projects that incorporate their area of interest.
- Make sure to point out and praise students for good choices.
- Offer continuous, authentic feedback.
- Not ridicule or criticize students. They should find a private place to talk with a child about a poor choice or behavior.
- Help students formulate their own alternate choices by guiding them to a more positive solution and outcome.
- When children experiment, they should not be punished for trying something that may turn out differently from what the teacher had planned.

At the elementary level, teachers should focus on achievement and peer relationships and

- Create a list of classroom duties that need to be completed on a scheduled basis. Ask students for their input when creating the list, as well as giving them a say in who will be in charge of what.
- Discuss and post classroom rules.
- Make sure to include students in the decision-making process when discussing rules.
- Encourage students to think outside of their day-to-day routine by role-playing different situations.
- Let students know that striving for perfection is not as important as learning from mistakes.
- Teach children resilience.
- Encourage children to help students who may be having trouble socially and/or academically.
- Never allow any child to make fun of or bully another child.
- Build confidence by recognizing success in what children do best.
- Provide a variety of choices when making an assignment so that students can express

themselves with a focus on their strengths.

https://rotel.pressbooks.pub/whole-child/chapter/psychosocial-theory-2/

During the middle and high school years, building identity and self-esteem should be part of a teacher's focus.

Classroom examples that can be incorporated at the Middle School and High School Level:

- Treat all students equally. Do not show favoritism to a certain group of students based on gender, race, ability,
  academic skills, sexual orientation, or socioeconomic status.
- Incorporate guest speakers and curriculum activities from as many areas as possible so as to expose students to many career choices.
- Encourage students to focus on their strengths and acknowledge them when they exhibit work that incorporates these strengths.
- Encourage students to develop confidence by trying different approaches to solving problems.
- Incorporate life skills into lesson planning to increase confidence and self-sufficiency.
- Utilize physical activity to help relieve stress, negative feelings and improve moods (Bianca, 2010).

https://openoregon.pressbooks.pub/educationallearningtheories3rd/chapter/chapter-8-psychosocial-theory-of-identity-development-2/

Review & Practice

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://uark.pressbooks.pub/edlearningtheory/?p=418#h5p-7

Critical Thinking

- How do Erikson's stages build upon one another, and what happens if a person does not successfully resolve a stage?
- Why does Erikson emphasize social relationships as the primary driver of development?
- How do the conflicts in each stage impact a person's identity and sense of self?
- What role does culture play in how people experience and resolve each psychosocial stage?
- How does Erikson's theory compare to Piaget's cognitive development stages?
- How does the concept of **identity vs. role confusion** in adolescence connect to the modern challenges of social media and peer pressure?

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CHAPTER 8: BIOECOLOGICAL SYSTEMS THEORY (URIE BRONFENBRENNER)

Learning Objectives

- Explain Bronfenbrenner's Bioecological Theory of Learner Development.
- Use Bronfenbrenner's Bioecological Systems to describe & explain how a person's experiences shape their life/identity.

Urie Bronfenbrenner (1917-2005) developed the Ecological Systems Theory (sometimes referred to as the Bioecological Theory), *which provides a framework for understanding and studying the many influences on human development* (Bronfenbrenner, 1979). Bronfenbrenner recognized that human interaction is influenced by larger social forces and that an understanding of these forces is essential for understanding an individual. The individual is impacted by several systems including:

- Microsystem *includes the individual's setting and those who have direct, significant contact with the person, such as parents or siblings*. The input of those is modified by the cognitive and biological state of the individual as well. These influence the person's actions, which in turn influence systems operating on him or her.
- Mesosystem *includes the larger organizational structures, such as school, the family, or religion.* These institutions impact the microsystems just described. The philosophy of the school system, daily routine, assessment methods, and other characteristics can affect the child's self-image, growth, sense of accomplishment, and schedule thereby impacting the child, physically, cognitively, and emotionally.
- Exosystem *includes the larger contexts of community*. A community's values, history, and economy can impact the organizational structures it houses. Mesosystems both influence and are influenced by the ecosystem.
- Macrosystem *includes the cultural elements,* such as global economic conditions, war, technological trends, values, philosophies, and a society's responses to the global community.

- Chronosystem *is the historical context in which these experiences occur.* This relates to the different generational time periods previously discussed, such as the baby boomers and millennials.

In sum, a child's experiences are shaped by larger forces, such as the family, schools, religion, culture, and time period. Bronfenbrenner's model helps us understand the different environments that impact each of us simultaneously. Despite its comprehensiveness, Bronfenbrenner's ecological system's theory is not easy to use. Taking into consideration all the different influences makes it difficult to research and determine the impact of all the different variables (Dixon, 2003). Consequently, psychologists have not fully adopted this approach, although they recognize the importance of the ecology of the individual. Figure 8.1 is a model of Bronfenbrenner's Ecological Systems Theory.

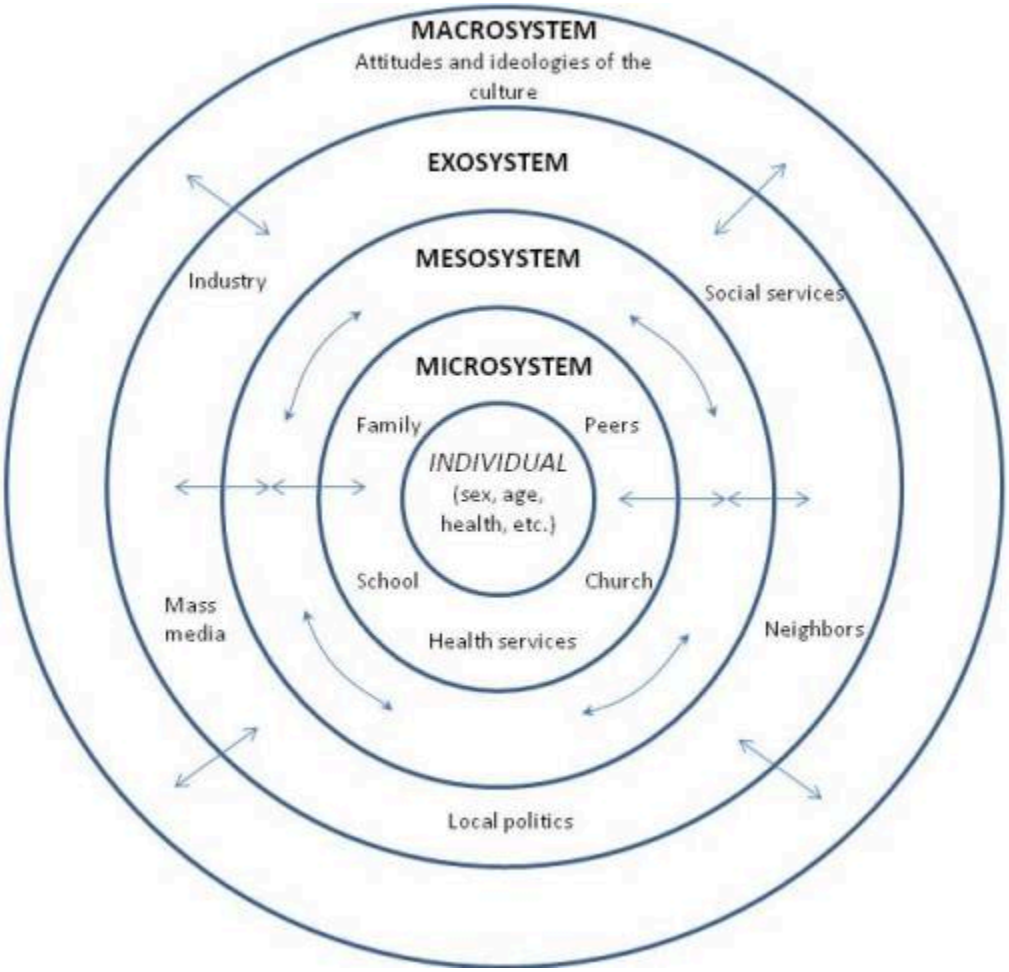

Figure 8.1 Bronfenbrenner's Ecological Systems Theory

Watch It

Bronfenbrenner's Ecological Theory

This short video from Professor Rachelle Tannenbaum of Anne Arundel Community College explains and gives examples of Brofenbrenner's theory. (See video transcript here.)

Self-Reflection & Critical Thinking

1. List 3-5 factors in your life that directly impact your daily life/learning.
2. What is an example of an interaction or a relationship between two factors in your microsystem that directly impacts your life?
3. List 1-2 social structures that indirectly influence your life/learning.
4. Make a list of 1-2 established social/cultural norms (attitudes, beliefs, cultural heritage..., etc.) that indirectly impact your life.
5. List 1-2 significant life transitions (expected or unexpected) and/or historical events that have indirectly impacted your life/identity.
6. How might your own experiences have shaped your personal identity?
7. How does learning about these bioecological systems impact your knowledge about your students (or future students)?

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PART III

UNIT THREE: LEARNER DIFFERENCES

CHAPTER 9: INTELLIGENCES THEORY

Learning Objectives

1. Define and describe the term *intelligence*.
2. Discuss different ways of measuring an individual's intellectual abilities.
3. Describe pros, cons, and nuances of using students' measures of intelligence for curriculum purposes.
4. Explain the controversy relating to differences in intelligence between groups.

Introduction

Every year, hundreds of grade school students converge in Washington, D.C., for the annual Scripps National Spelling Bee. The "bee" is an elite event in which children as young as 8 square off to spell words like "cymotrichous" and "appoggiatura." Most people who watch the bee think of these kids as being "smart" and you likely agree with this description.

Figure 9.1 A participant in the Scripps National Spelling Bee

What makes a person intelligent? Is it heredity (two of the 2014 contestants in the bee have siblings who have previously won)(National Spelling Bee, 2014a)? Is it interest (the most frequently listed favorite subject among spelling bee competitors is math)(NSB, 2014b)? What are some issues related to using intelligence measurements to describe students' academic abilities? In this module, we will cover these and other fascinating aspects of intelligence. By the end of the module you should be able to define intelligence and discuss some common strategies for measuring intelligence. In addition to discussing issues related to the various intelligence theories, we will also tackle the politically thorny issue of whether there are differences in intelligence between groups such as men and women.

Defining Intelligence

When you think of "smart people," you likely have an intuitive sense of the qualities that make them intelligent. Maybe you think they have a good memory, or that they can think quickly, or that they simply know a whole lot of information. Indeed, people who exhibit such qualities appear very intelligent. That said, it seems that intelligence must be more than simply knowing facts and being able to remember them.

The question of what constitutes human intelligence is one of the oldest inquiries in psychology. When we

talk about intelligence, we typically mean intellectual ability. This broadly encompasses the ability to learn, remember, and use new information, to solve problems, and to adapt to novel situations.

Types of Intelligence

General Intelligence (g factor)

British psychologist Charles Spearman believed intelligence consisted of one general factor, called g (or g factor), which could be measured and compared among individuals. Spearman focused on the commonalities among various intellectual abilities and de-emphasized what made each unique. He based this conclusion on the observation that people who perform well in one intellectual area, such as verbal ability, also tend to perform well in other areas, such as logic and reasoning (Spearman, 1904).

Fluid and Crystallized Intelligence

Other psychologists believe that intelligence is a collection of distinct abilities rather than a single factor. In the 1940s, Raymond Cattell proposed a theory of intelligence that divided general intelligence into two components: crystallized intelligence and fluid intelligence (Cattell, 1963).

Crystallized intelligence is acquired knowledge from education, experiences, and skills gained over time. When you learn, remember, and recall information, you are using crystallized intelligence. You use crystallized intelligence all the time in your coursework by demonstrating that you have mastered the information covered in the course. Crystallized intelligence increases with age as people learn more facts and concepts. Some examples of crystallized intelligence follows:

- Knowing historical facts or vocabulary words
- Solving math problems using learned formulas
- Giving directions in your hometown
- Using prior business experience to manage a new project.
- Reading comprehension and understanding complex texts.

Fluid intelligence encompasses the ability to solve brand-new, complex problems. Fluid intelligence helps you tackle complex, abstract challenges in unfamiliar contexts in daily life. For example, navigating home after being detoured onto an unfamiliar route because of road construction would draw upon your fluid intelligence. Another example might also include the following:

- Figuring out how to fix a broken device without instructions.
- Finding your way around in a place you have never been before

- Solving a new puzzle without instructions.
- Recognizing patterns in a sequence of numbers.

Other theorists and psychologists believe intelligence should be defined more practically. For example, what types of behaviors help you get ahead in life? Which skills promote success? Think about this for a moment. Being able to recite all 44 presidents of the United States in order is an excellent party trick, but will knowing this make you a better person?

Triarchic Theory of Intelligence

Robert Sternberg developed another theory of intelligence, which he titled the triarchic theory of intelligence because it sees intelligence as comprised of three parts (Sternberg, 1988): practical, creative, and analytical intelligence (Figure 9.2).

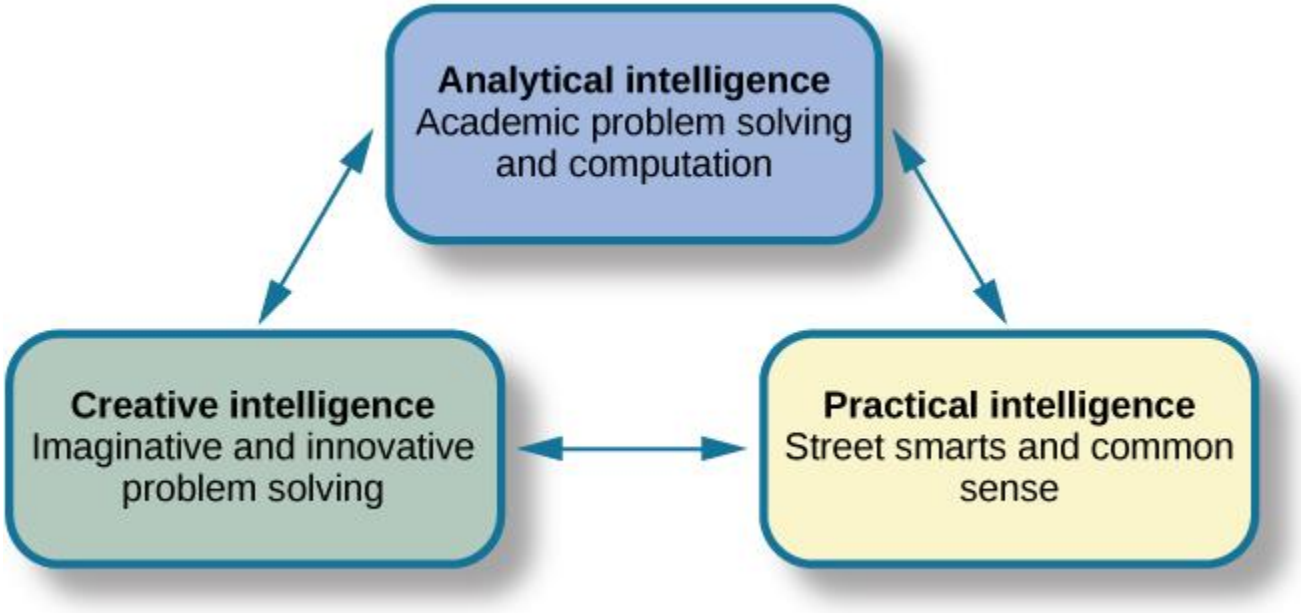

Figure 9.2 Sternberg's theory identified three types of intelligence: practical, creative, and analytical.

As Sternberg proposed, practical intelligence is sometimes compared to "street smarts." Being practical means you find solutions that work in your everyday life by applying knowledge based on your experiences. This type of intelligence appears to be separate from the traditional understanding of IQ; individuals who score high in practical intelligence may or may not have comparable scores in creative and analytical intelligence (Sternberg, 1988).

This story about the 2007 Virginia Tech shootings illustrates both high and low practical intelligences. During the incident, one student left her class to go get a soda in an adjacent building. She planned to return to class, but when she returned to her building after getting her soda, she saw that the door she used to leave

was now chained shut from the inside. Instead of thinking about why there was a chain around the door handles, she went to her class's window and crawled back into the room. She thus potentially exposed herself to the gunman. Thankfully, she was not shot. On the other hand, a pair of students was walking on campus when they heard gunshots nearby. One friend said, "Let's go check it out and see what is going on." The other student said, "No way, we need to run away from the gunshots." They did just that. As a result, both avoided harm. The student who crawled through the window demonstrated some creative intelligence but did not use common sense. She would have low practical intelligence. The student who encouraged his friend to run away from the sound of gunshots would have much higher practical intelligence.

Analytical intelligence is closely aligned with academic problem-solving and computations. Sternberg says that analytical intelligence is demonstrated by an ability to analyze, evaluate, judge, compare, and contrast. When reading a classic novel for literature class, for example, it is usually necessary to compare the motives of the book's main characters or analyze the story's historical context. In a science course such as anatomy, you must study how the body uses various minerals in different human systems. In developing an understanding of this topic, you are using analytical intelligence. When solving a challenging math problem, you would apply analytical intelligence to analyze different aspects of the problem and then solve it section by section.

Creative intelligence is marked by inventing or imagining a solution to a problem or situation. Creativity in this realm can include finding a novel solution to an unexpected problem or producing a beautiful work of art or a well-developed short story. Imagine for a moment that you are camping in the woods with some friends and realize you've forgotten your camp coffee pot. The person in your group who can successfully brew coffee for everyone would be credited with having higher creative intelligence.

Multiple Intelligences

Multiple Intelligences Theory was developed by Howard Gardner, a Harvard psychologist and former student of Erik Erikson. Gardner's theory, which has been refined for more than 30 years, is a more recent development among theories of intelligence. In Gardner's theory, each person possesses at least eight intelligences. (See Figure 9.3 below for a visual of these eight intelligences.)

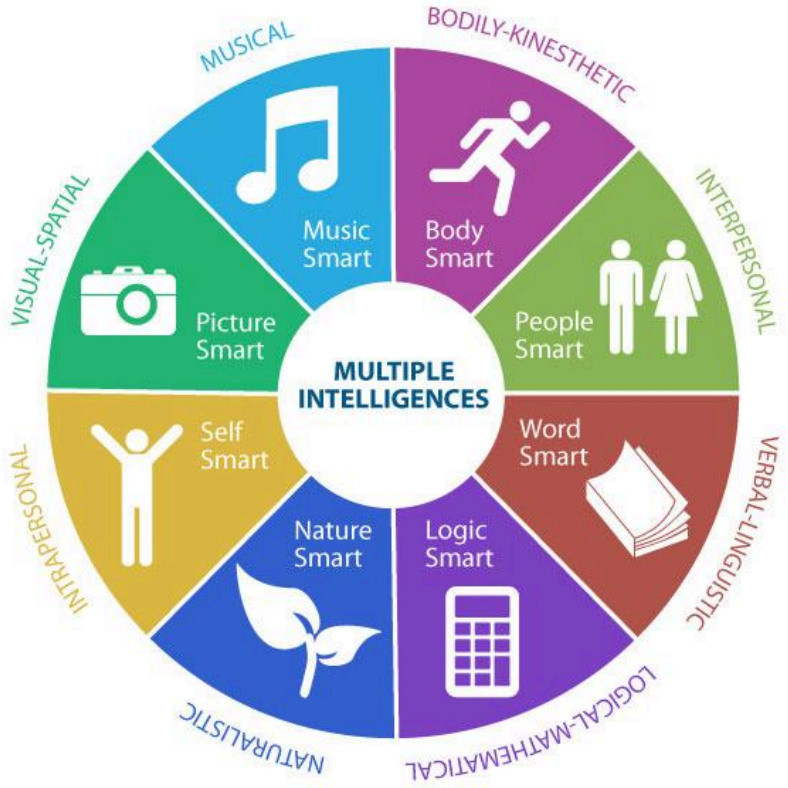

Figure 9.3 Multiple intelligences theory proposed by Gardner.

Among these eight intelligences, a person typically excels in some and falters in others (Gardner, 1983). See Table 1 below for a more thorough description of each form of intelligence.

Table 1: Characteristics of the Eight Multiple Intelligences and Corresponding Careers

Intelligence Type	Characteristics
Linguistic intelligence	Perceives different functions of language, different sounds and meanings of words, may easily le
Logical-mathematical intelligence	Capable of seeing numerical patterns, strong ability to use reason and logic
Musical intelligence	Understands and appreciates rhythm, pitch, and tone; may play multiple instruments or perfor
Bodily kinesthetic intelligence	High ability to control the movements of the body and use the body to perform various physica
Spatial intelligence	Ability to perceive the relationship between objects and how they move in space
Interpersonal intelligence	Ability to understand and be sensitive to the various emotional states of others
Intrapersonal intelligence	Ability to access personal feelings and motivations, and use them to direct behavior and reach p
Naturalist intelligence	High capacity to appreciate the natural world and interact with the species within it

Importantly, Gardner's theory is relatively new and needs additional research to establish empirical support better although developing traditional measures of Gardner's intelligences would be extremely difficult (Furnham, 2009; Despite their being a strong belief in MI, a vast number of researchers assert there is no valid evidence supporting the idea that individuals have separate brain-based intelligences that vary in strength (Waterhouse, 2023). However, Gardner's ideas challenged the traditional notion of intelligence to include a wider variety of abilities.

Emotional Intelligence

Emotional intelligence encompasses the ability to understand the emotions of yourself and others (see Figure 9.4), show empathy, understand social relationships and cues, regulate your emotions, and respond in culturally appropriate ways (Parker, Saklofske, & Stough, 2009).

Figure 9.4: Image to reflect emotional intelligence and a person's ability to discern their own and others' emotions.

People with high emotional intelligence typically have well-developed social skills. Some researchers, including Daniel Goleman, the author of Emotional Intelligence: Why It Can Matter More than IQ, argue that emotional intelligence is a better predictor of success than traditional intelligence (Goleman, 1995). However, emotional intelligence has been widely debated, with researchers pointing out inconsistencies in how it is defined and described, as well as questioning results of studies on a subject that is difficult to measure and study empirically (Locke, 2005; Mayer, Salovey, & Caruso, 2004). (Note: Gardner's inter- and intrapersonal intelligences are often combined into a single type of Emotional Intelligence.)

Multicultural Perspectives of Intelligence

Intelligence can also have different meanings and values in different cultures. If you live on a small island, where most people get their food by fishing from boats, it would be important to know how to fish and how to repair a boat. If you were an exceptional angler, your peers would probably consider you intelligent. If you were also skilled at repairing boats, your intelligence might be known across the whole island. Think about your own family's culture. How do they conceptualize intelligence?

What values are important for Latino families? Italian families? In Irish families, hospitality and telling an entertaining story are marks of the culture. If you are a skilled storyteller, other Irish culture members will likely consider you intelligent.

Some cultures place a high value on working together as a collective. In these cultures, the importance of the group supersedes the importance of individual achievement. When you visit such a culture, how well you relate to the values of that culture exemplifies your cultural intelligence, sometimes referred to as cultural competence.

Measuring Intelligence

Alfred Binet is best known for formally pioneering the measurement of intellectual ability. Binet was fascinated by individual differences in intelligence. For instance, he blindfolded chess players and saw that some of them could continue playing using only their memory to remember the many positions of the pieces (Binet, 1894). Binet was particularly interested in intelligence development, a fascination that led him to closely observe children in the classroom setting.

Figure 9.5 French psychologist Alfred Binet helped to develop intelligence testing.

Along with his colleague Theodore Simon, Binet created a test of children's intellectual capacity. They created individual test items that should be answerable by children of given ages. For instance, a three-year-old child should be able to point to her mouth and eyes, a nine-year-old should be able to name the months of the year in order, and a twelve-year-old should be able to name sixty words in three minutes. Their assessment became the first "IQ test."

Sample IQ Questions

1. Which of the following is the most similar to 1313323?

A. ACACCBC

B. CACAABC

C. ABABBCA

D. ACACCDC

2. Jenny has some chocolates. She eats two and gives half of the remainder to Lisa. If Lisa has six chocolates, how many chocolates does Jenny have in the beginning?

A. 6

B. 12

C. 14

D. 18

Which of the following items is not like the others in the list?

duck, raft, canoe, stone, rubber ball

A. Duck

B. Canoe

C. Stone

D. Rubber ball

What do steam and ice have in common?

A. They can both harm skin

B. They are both made from water

C. They are both found in the kitchen

D. They are both the products of water at extreme temperatures

Answers: 1)A; 2)C; 3)Stone; 4)D is the most sophisticated answer

"IQ" or "intelligence quotient" is a name given to the score of the Binet-Simon test. The score is derived by dividing a child's mental age (the score from the test) by their chronological age to create an overall quotient.

These days, the phrase "IQ" does not apply specifically to the Binet-Simon test and is generally used to denote intelligence or a score on any intelligence test. In the early 1900s, the Binet-Simon test was adapted by a Stanford professor named Lewis Terman to create what is, perhaps, the most famous intelligence test in the world, the Stanford-Binet (Terman, 1916).

The significant advantage of this new test was that it was standardized to US populations.. Based on a large sample of children, Terman could plot the scores in a normal distribution, shaped like a "bell curve" (see Figure 9.6). To understand a normal distribution, think about the height of people. Most people are average in height with relatively fewer being tall or short, and fewer still being extremely tall or extremely short. Terman (1916) laid out intelligence scores exactly the same way, allowing for easy and reliable categorizations and individual comparisons.

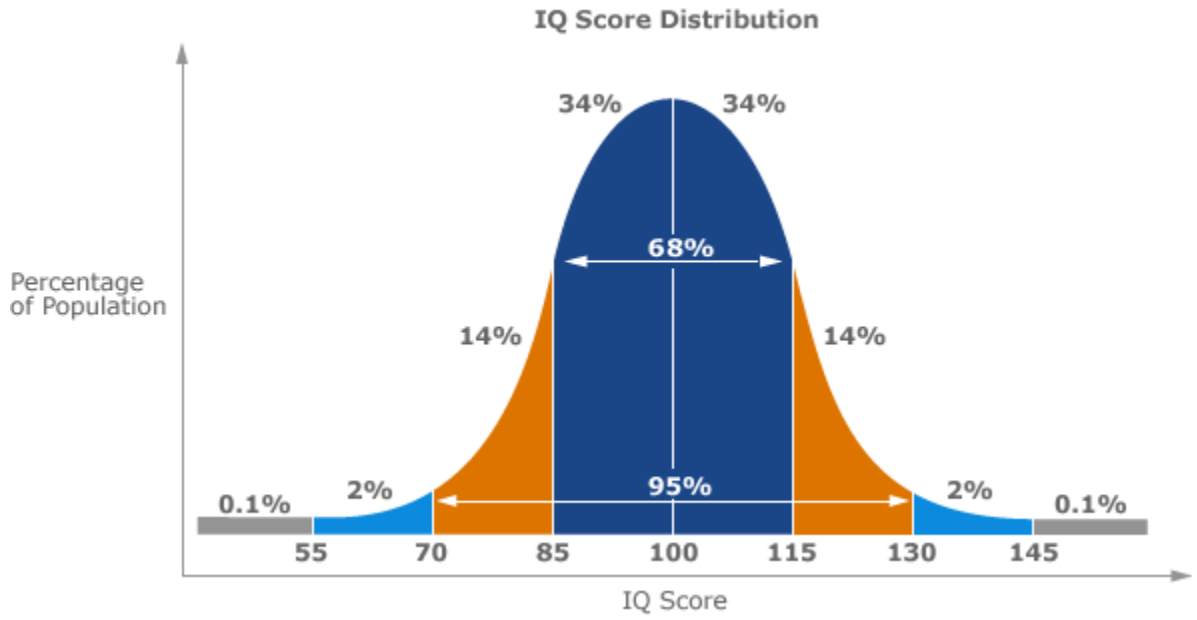

Figure 9.6 Bell Curve- Normal Distribution IQ

Looking at another modern intelligence test—the Wechsler Adult Intelligence Scale (WAIS)—can provide clues to a definition of intelligence itself. Motivated by several criticisms of the Stanford-Binet test, psychologist David Wechsler sought to create a superior measure of intelligence. He was critical of how the Stanford-Binet relied so heavily on verbal ability and was also suspicious of using a single score to capture all of intelligence. Wechsler created a test to address these issues that tapped various intellectual abilities. This understanding of intelligence—that it is made up of a pool of specific abilities—is a notable departure from Spearman's concept of general intelligence. The WAIS assesses people's ability to remember, compute, understand language, reason well, and process information quickly (Wechsler, 1955).

Flynn Effect

One interesting by-product of measuring intelligence for so many years is that we can chart changes over time. It might seem strange to you that intelligence can change over the decades, but that appears to have happened over the last 80 years as we have been measuring this topic. Here's how we know: IQ tests have an average score of 100. When new waves of people are asked to take older tests, they tend to outperform the original sample from years ago, when the test was normed. This gain is known as the "Flynn Effect," named after James Flynn, the researcher who first identified it (Flynn, 1987). Several hypotheses have been put forth to explain the Flynn Effect, including better nutrition (healthier brains!), greater general familiarity with testing, and more visual stimuli. Today, there is no perfect agreement among psychological researchers with regard to the causes of increases in average scores on intelligence tests. Perhaps if you choose a career in psychology, you will be the one to discover the answer!

Effect of Mindset on Intelligence

There is one last point that is important to bear in mind about intelligence. It turns out that the way an individual thinks about his or her own intelligence is also important because it predicts performance. Researcher Carol Dweck has made a career out of looking at the differences between high IQ children who perform well and those who do not, so-called "underachievers." Among her most interesting findings is that it is not gender or social class that sets apart the high and low performers. Instead, it is their mindset. The children who believe that their abilities in general—and their intelligence specifically—is a fixed trait tend to underperform. By contrast, kids who believe that intelligence is changeable and evolving tend to handle failure better and perform better (Dweck, 1986). Dweck refers to this as a person's "mindset" and having a growth mindset appears to be healthier.

The research on mindset is interesting, but there can also be a temptation to interpret it as suggesting that every human has an unlimited potential for intelligence and that becoming smarter is only a matter of positive thinking. There is some evidence that genetics is an important factor in the intelligence equation. For instance, a number of studies on genetics in adults have yielded the result that intelligence is largely, but not totally, inherited (Bouchard,2004). Having a healthy attitude about the nature of smarts and working hard can both definitely help intellectual performance, but it also helps to have the genetic leaning toward intelligence.

Bias and Group Differences

Carol Dweck's research on the mindset of children also brings one of the most interesting and controversial issues surrounding intelligence research to the fore: group differences. From the very beginning of the study of intelligence, researchers have wondered about differences between groups of people such as men and women. With regards to potential differences between the sexes some people have noticed that women are

under-represented in certain fields. In 1976, for example, women comprised just 1% of all faculty members in engineering (Ceci, Williams & Barnett, 2009).

Figure 9.7 Women account for a disproportionately small percentage of those employed in math-intensive career fields such as engineering.

Even today, women comprise between 3% and 15% of all faculty in math-intensive fields at the 50 top universities. This phenomenon could be explained in many ways: it might be the result of inequalities in the educational system, it might be due to differences in socialization wherein young girls are encouraged to develop other interests, it might be the result of that women are—on average—responsible for a larger portion of childcare obligations and therefore make different types of professional decisions, or it might be due to innate differences between these groups, to name just a few possibilities. The possibility of innate differences is the most controversial because many people see it as either the product of or the foundation for sexism. In today's political landscape, it is easy to see that asking certain questions such as "Are men smarter than women?" would be inflammatory. In a comprehensive review of research on intellectual abilities and sex, Ceci and colleagues (2009) argue against the hypothesis that biological and genetic differences account for much of the sex differences in intellectual ability. Instead, they believe that a complex web of influences ranging from societal expectations to test-taking strategies to individual interests account for many of the sex differences found in math and similar intellectual abilities.

A more interesting question, and perhaps a more sensitive one, might be to inquire in which ways men and women might differ in intellectual ability, if at all. That is, researchers should not seek to prove that one group or another is better but might examine how they differ and offer explanations for any differences that are found. Researchers have investigated sex differences in intellectual ability. In a review of the research literature, Halpern (1997) found that women appear, on average, superior to men in fine motor skills, acquired knowledge, reading comprehension, decoding non-verbal expression, and generally have higher grades in school. Men, by contrast, appear, on average, superior to women on measures of fluid reasoning related to math and science, perceptual tasks that involve moving objects, and tasks that require transformations in working memory, such as mental rotations of physical spaces. Halpern also notes that men are disproportionately represented on the low end of cognitive functioning, including in intellectual disability, dyslexia, and attention deficit disorders (Halpern, 1997).

Other researchers have examined various explanatory hypotheses for why sex differences in intellectual ability occur. Some studies have provided mixed evidence for genetic factors while others point to evidence for social factors (Neisser, et al, 1996; Nisbett, et al., 2012). One interesting phenomenon that has received research scrutiny is the idea of stereotype threat. Stereotype threat is the idea that mental access to a particular stereotype can have real-world impact on a member of the stereotyped group. In one study (Spencer, Steele, & Quinn, 1999), for example, women who were informed that women tend to fare poorly on math exams just before taking a math test performed worse than a control group who did not hear the stereotype. Research on stereotypes has yielded mixed results, and we are currently uncertain exactly how and when this effect might occur. One possible antidote to stereotype threat, at least in the case of women, is to make a self-affirmation (such as listing positive personal qualities) before the threat occurs. In one study, for instance, Martens and her colleagues (2006) had women write about personal qualities that they valued before taking a math test. The affirmation largely erased the effect of stereotype by improving math scores for women relative to a control group but similar affirmations had little effect for men (Martens, Johns, Greenberg, & Schimel, 2006).

These types of controversies compel many laypeople to wonder if there might be a problem with intelligence measures. It is natural to wonder if they are somehow biased against certain groups. Psychologists typically answer such questions by pointing out that bias in the testing sense of the word is different than how people use the word in everyday speech. Common use of bias denotes a prejudice based on group membership. Scientific bias, on the other hand, is related to the psychometric properties of the test such as validity and reliability. Validity is the idea that an assessment measures what it claims to measure and that it can predict future behaviors or performance. To this end, intelligence tests are not biased because they are fairly accurate measures and predictors. There are, however, real biases, prejudices, and inequalities in the social world that might benefit some advantaged group while hindering some disadvantaged others.

Conclusion

Although you might not be able to spell “esquamulose” or “staphylococci”, you might not even know what

they mean, you don't need to count yourself out in the intelligence department. Now that we have examined intelligence in depth, we can return to our intuitive view of those students who compete in the National Spelling Bee. Are they smart? Certainly, they seem to have high verbal intelligence. There is also the possibility that they benefit from either a genetic boost in intelligence, a supportive social environment, or both. Watching them spell difficult words, we also do not know much about them. We cannot tell, for instance, how emotionally intelligent they are or how they might use bodily-kinesthetic intelligence. This highlights the fact that intelligence is a complicated issue. Fortunately, psychologists continue to research this fascinating topic, and their studies continue to yield new insights.

External Links to Learning

1. Developing Emotional Intelligence (for children ages 4-12) (OER Commons)
2. Multiple Intelligences Theory: Widely Used, Yet Misunderstood (Edutopia)
3. Harvard researcher says the most emotionally intelligent people have these 12 traits. Which do you have? (Goleman, 2021)
4. See the Interactive CASEL Wheel (See about CASEL)
5. Intelligence is Fixed (Center for Educational Research)
6. Cultural Perceptions of Human Intelligence (Cocodia, 2014)
7. Finding the Next Einstein | Psychology Today (blog) An excellent blog discussing many of the most interesting issue related to intelligence
8. Controversy of Intelligence: Crash Course Psychology #23 (YouTube Video)-Hank Green gives a fun and interesting overview of the concept of intelligence in this installment of the Crash Course series.

Self-Reflection & Critical Thinking

1. What about the intelligence theory surprises you?
2. What intelligence theory did you find most compelling? Why?
3. How does knowing about intelligence theory impact you as a learner? Your perception of other learners?

4. What are some practical teaching implications of intelligence theory?
5. How does intelligence theory inform assessment practices?
6. Define intelligence in your own words in a way that reflects its complex and multifaceted nature.
7. Construct a model of intelligence to reflect your understanding of its complex nature.

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PART IV

UNIT FOUR: MAJOR LEARNING THEORIES

CHAPTER 10: BEHAVIORAL VIEW OF LEARNING

Learning Objectives

1. Define behaviorism and explain its emphasis on observable behavior and stimulus-response relationships.
2. Differentiate between classical conditioning, operant conditioning, and observational learning as behaviorist approaches.
3. Apply behaviorist strategies such as reinforcement, punishment, shaping, modeling, and cueing to classroom management and instruction.
4. Critically evaluate the limitations of behaviorism and consider additional factors (e.g., emotions, culture, learning differences) that influence student behavior.

Classroom Scenario:

Mr. Mack was a brand new fifth grade teacher, full of hope, creative ideas and good intentions. However, he was stumped as to how to get his student Johnny to stay in his seat. Sometimes, Johnny would throw chairs out of frustration, and other times Mr. M could not even get a word out of him. Mr. M tried to get Johnny to look him in the eye as he was giving instructions, thinking that this would help Johnny to focus on the task at hand; this proved to be very challenging. Sometimes Mr M could just tell that Johnny was about to bolt outside and so he would warn Johnny to stay in his seat,

letting him know that if he left his chair he would have to miss recess. Unfortunately, Johnny

often had to miss recess and stay inside by himself. Mr. M felt exhausted and defensive when he had to consult with the school counselor. The counselor offered to come and observe the classroom and discuss possible strategies for helping Johnny and Mr. M.

As you read this chapter on behaviorism, consider how behaviorist strategies could help both Mr. M and Johnny to have a more productive relationship, and a better teaching and learning experience.

Introduction

Basic principles of learning are always operating and always influencing human behavior. This module discusses the two most fundamental forms of learning — classical and operant conditioning. Through them, we respectively learn to associate 1) stimuli in the environment, or 2) our own behaviors, with significant events, such as rewards and punishments. The two types of learning have been intensively studied because they have powerful effects on behavior, and because they provide methods that allow scientists to analyze learning processes rigorously. This module describes some of the most important things you need to know about classical and operant conditioning, and it illustrates some of the we can use it to help us understand and modify student behavior to enhance the learning environment. The module also introduces the concept of observational learning, which is a form of learning that is largely distinct from classical and operant conditioning but is intricately related to Behaviorism. Lastly this module discusses educational implications of Behaviorism and its limitations as a learning theory.

What is Behaviorism?

Key Idea: If a student starts turning in homework more often after being praised, that change in behavior suggests learning has occurred.

Behaviorism focuses on observable behaviors—what people do—not internal thoughts or emotions. According to behaviorist theories, behavior is shaped by environmental stimuli and the responses they trigger.

Learning occurs through the formation of stimulus-response associations, and change in behavior is the key sign that learning has occurred [1].

Behaviorists like Watson and Skinner argue that only measurable, external behaviors are valid for study—not feelings, beliefs, or inner mental processes. Instead, they propose that behavior is learned through interaction with the environment.

External Links to Learning

1. Behaviorism: Pavlov, Watson, and Skinner (YouTube)

Types of Conditioning

Classical Conditioning (Pavlov and Watson)

Classical conditioning happens when a neutral stimulus becomes associated with a stimulus that naturally produces a response. Over time, the neutral stimulus triggers the same response on its own. Consider the two examples below:

- Example: Pavlov's dog experiment: a bell (neutral) is paired with food (unconditioned stimulus), causing the dog to salivate (unconditioned response). Eventually, the bell alone causes salivation (conditioned response).
- Classroom Example: A student hears a specific tone signaling lunch. Over time, that tone triggers hunger or excitement, even before food is present.

1. Parkay, F. W., & Hass, G. (2000). *Curriculum planning* (7th ed.). Needham Heights, MA: Allyn & Bacon.

In classical conditioning, a person or animal learns to associate a neutral stimulus (the conditioned stimulus, or CS) with a stimulus (the unconditioned stimulus, or US) that naturally produces a behaviour (the unconditioned response, or UR). As a result of this association, the previously neutral stimulus comes to elicit the same response (the conditioned response, or CR).

Operant Conditioning (Skinner)

While classical conditioning focuses on associations, operant conditioning focuses on consequences of behavior. Skinner showed that behaviors followed by rewards are more likely to be repeated. Likewise, behaviors that are punished are likely to be extinguished. In education, advocates of behaviorism have effectively adopted this system of rewards and punishments in their classrooms by rewarding desired behaviors and punishing inappropriate ones. Rewards (reinforcements) vary, but must be important to the learner in some way.

- Positive reinforcement: Adding a reward to increase behavior. Some examples follow:
  - Smiling at students after they speak up in class in response.
  - Commending students for raising their hands to speak.
  - Selecting them for a special project, and
  - Praising students in front of their parents.
- Negative reinforcement: Removing something unpleasant to increase behavior. Some examples follow:
  - If you submit all your assignments, I'll drop the lowest grade
  - 80% attendance and a grade of A -B make the final test optional
- Positive punishment: Adding something to decrease behavior. Some examples follow:
  - Detention for misbehavior
  - 0 for not turning in an assignment
  - Sent to the principal's office for misbehavior
- Negative punishment: Taking something away to decrease behavior.
  - No recess
  - Remove toys because students are not playing with them appropriately

See Table 1 for examples of how teachers can use operant conditioning to modify student behavior.

Table 1. Operant Conditioning in Action

Strategy	What It Does
Positive Reinforcement	Increases behavior by adding something
Negative Reinforcement	Increases behavior by removing something
Positive Punishment	Decreases behavior by adding something
Negative Punishment	Decreases behavior by removing something

Shaping is a strategy teachers can use to reinforce small steps toward a desired behavior.

- A student who never raises their hand begins by whispering the answer, speaks up in small groups, and eventually shares during class.
- Mr. B would like his class to sit quietly after entering the classroom, but they continue talking after the bell rings. Mr. B gives the class one point for improvement, in that all students are seated. Subsequently, the students must be seated and quiet to earn points, which may be accumulated and redeemed for rewards.

Critical Thinking

1. How would you use reinforcement to encourage participation in a quiet class?
2. What is a real classroom example of negative reinforcement? Why is it often misunderstood?
3. Considering what you've learned about classical and operant conditioning, how might Mr. Mack in the intro scenario use these reinforcements to motivate Johnny?

Observational Learning (Bandura)

"Of the many cues that influence behavior, at any point in time, none is more common than the actions of others" [2].

Not all forms of learning are accounted for entirely by classical and operant conditioning. Albert Bandura

2. Bandura, A. (1986). *Social foundation of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

introduced social learning theory, arguing that people can learn by watching others. This is called *modeling* or *observational learning*.

Imagine a child walking up to a group of children playing a game on the playground. The game looks fun, but it is new and unfamiliar. Rather than joining the game immediately, the child opts to sit back and watch the other children play a round or two. Observing the others, the child takes note of the ways in which they behave while playing the game. By watching the behavior of the other kids, the child can figure out the rules of the game and even some strategies for doing well at the game.

External Links to Learning

Researchers have conducted countless experiments designed to explore observational learning, the most famous of which is Albert Bandura's Bobo doll experiment: Children who observed adults acting aggressively toward a toy were more likely to mimic that behavior.

- Bobo Doll Experiment (YouTube)
- The Bobo Beatdown Crash Course Psychology #12

More Classroom Examples of Observational Learning

- Students may pick up on behaviors modeled by peers, teachers, or even media. A student who watches classmates raise their hand may begin to do the same.
- The 10th grade biology teacher models how to properly use a microscope. Students replicate her instructions without written instructions just by remembering what they observed.
- A child who kicks another child after seeing this on the playground.
- A student who is always late for class because his friends are late is displaying the results of observational learning.

Critical Thinking

1. How could modeling be used to help students learn appropriate behavior?

Behavior Management Tools

Behaviorism has contributed many practical classroom strategies

- **Cueing**: Giving reminders
  - Example: Mrs. R is working with Danny, who often answers aloud instead of raising his hand. At the end of asking a question, Mrs. R says to the class, "I'll call on someone who is raising their hand," to help Danny remember to perform an action (hand raising) at a specific time (when a question is asked).
- **Contracts**: Agreements between teacher and student to change a behavior
- **Reinforcement schedules**: Using consistent or occasional rewards (See OER Reinforcement Schedules -near bottom of the page)
- **Behavior modification plans**: Targeted support for students needing behavioral change

Limitations of Behaviorism

While behaviorism provides powerful tools, it has limitations:

- It may overlook internal processes like emotion, motivation, and cognition.
- It may not account for cultural, developmental, or individual differences.
- Some students need more than rewards or punishments—they need relationships, scaffolding, or emotional support.

Additional factors that affect learning may include (not a full list):

- Learning differences
- Socioeconomic status
- Gender identity
- Cultural background
- Disabilities
- Psychological or social emotional

Critical Thinking

1. Explain some effective ways to change behaviors.
2. How could modeling be used to help students learn appropriate behavior?
3. What are the limitations of relying only on behaviorism in diverse classrooms?
4. Would behaviorist strategies alone be enough to support Johnny? What else might Mr. Mack need to consider?
5. What else should you consider when attempting to modify behavior? What other factors do you think impact an individual's behavior?

Key Takeaways

- Behaviorism focuses on observable behavior and environmental stimuli.
- Classical and operant conditioning shape behavior in different ways.
- Reinforcement, punishment, modeling, and shaping are powerful tools in classroom management.
- Observational learning highlights the power of social models.
- Effective teaching combines behaviorist strategies with an understanding of the whole child.

Review & Practice

1. What is behaviorism primarily concerned with, and what does it consider the legitimate object of study?
2. How does classical conditioning work, and what are the roles of the US, UR, CS, and CR?
3. What is operant conditioning, and how is it different from classical conditioning?
4. Define and give examples of positive reinforcement, negative reinforcement, and punishment in a classroom setting.
5. What is shaping, and how can it be used to promote desired behaviors over time?
6. How does cueing help reinforce expected classroom behaviors?
7. What are two major criticisms of behaviorism in relation to individual learning differences?

8. What is observational learning, and how does it differ from other behaviorist strategies?
9. How might behaviorism be used effectively in classroom management while still addressing students' emotional or cultural needs?
10. What are two major criticisms of behaviorism in relation to individual learning differences?

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CHAPTER 11: COGNITIVE VIEWS OF LEARNING: MEMORY AND INFORMATION PROCESSING

Learning Objectives

1. Explain the cognitive model of memory, including sensory memory, working memory, and long-term memory.
2. Describe how attention and rehearsal influence memory encoding and retrieval.
3. Analyze how memory processing affects learning and instruction in the classroom.

Learning and Memory

The world is not static. It is dynamic and uncertain. Organisms compete and forage for scarce resources. To survive and thrive in this dynamic and uncertain environment while competing and foraging for scarce resources, we need to constantly adapt. Learning is what enables us to adapt to our environment – to succeed in uncertainty and among competition. Learning is acquiring information about the world. It involves exploring and making sense of our world.

Learning is a dynamic-over-time process that relies both on perceptual-short term processing and a short-to-long term establishment of learning in brain circuits. The constant retrieval and revision of learned concepts and skills, by means of review and experience, make the learnings more confident, durable and useful. This means that better acquisition is achieved when links to prior knowledge networks are more abundant. In other words, connections between what's being learned and what's been previously learned (and is relevant to the new learning) are established [1].

1. Quartz, S. R. (1999). The constructivist brain. Trends in Cognitive Sciences, 3(2), 48–57. doi: 10.1016/S1364-6613(98)01270-4.

Memory is the system that retains our information about the world. Memory enhances our abilities to perform within our world [2]. In other words, learning can be thought of as the process of acquiring information about the world; and memory the process of retaining that information. Despite what many once thought, memory does not only relate to memorization[3]. Our aim is to clarify the terms, prevent misconceptions, and build bridges between the communities. In this case, the educational community typically thinks of memory as being the process of individually and repeatedly memorizing some kind of content. In this book, memory refers to the biological process and cognitive function in which categorical (concept) or skill learning is established within the circuits of the brain. Importantly, the ways of acquiring and consolidating such types of learning involve much more than repeated memorization. Educational strategies such as peer learning, the use of imagery, recall practice, and/or active learning involving retrieval and elaboration of learning are emphasized.[/footnote]. It is not only activated when needed to retrieve facts. Rather, our current understanding is that our memory systems hold facts, habits, skills, and thoughts – memory underlies all that we can do and think. It is critical to learning and living. We cannot learn without the involvement of our memory system [5].

To acquire information (e.g. learn) we have to be aware of the information and store the information – learning and memory are part of the same adaptive system. A system that enhances our ability to make accurate predictions for future actions. Thus, learning requires memory. So, it is learning (and memory) that enables us to adapt to our environment.

Critical Thinking

1. How would you define learning from a cognitive perspective?

2. Goelet, P., Castellucci, V. F., Schacher, S., & Kandel, E. R. (1986). The long and the short of long–term memory—a molecular framework. Nature, 322(6078), 419-422.

3. It is important to note that some terms used in this book may have different meanings for the educational community and the scientific community [4]Devonshire, I. M., & Dommett, E. J. (2010). Neuroscience: viable applications in education?. The Neuroscientist, 16(4), 349-356.

4.

5. Squire, L. R., & Dede, A. J. (2015). Conscious and unconscious memory systems. *Cold Spring Harbor perspectives in biology, 7*(3), a021667.

Types of Memory

The 3-stage (or multi-store) model of memory is a traditional yet prevailing model of memory. Yet, it should be noted that it is also a model that is still under development by cognitive (neuro)scientists. In the model, there are three types of memory: (1) Sensory memory, (2) Short-term (working) memory (STM), (3) Long-term memory (LTM).

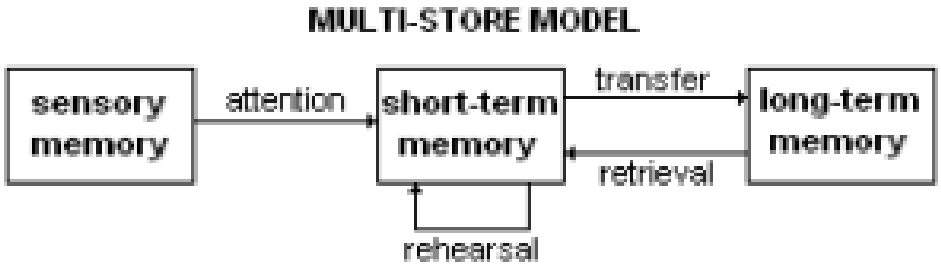

Figure 11.1 3-stage or multi-store model of memory (source: Wikipedia)

Sensory Memory

Sensory memory is an automatic process related to perception. "Sensory memory refers to the automatic, transient storage of the sensory features of incoming stimuli for subsequent integration with previously presented stimuli and or recalled information" [6]. Our senses are constantly collecting information from our environment. This information is always available to us. When we move our attention (focus) or our attention is pulled to one of the senses, then we become consciously aware of that information. This awareness signals that sensory information has moved into our working memory (which is part of STM). At any time we can move our attention to any one of our senses to check the incoming information. Short-term memory (STM) "reflect faculties of the human mind that can hold a limited amount of information in a very accessible state temporarily" [7].

6. Alain, C., Woods, D. L., & Knight, R. T. (1998). A distributed cortical network for auditory sensory memory in humans. *Brain research, 812*(1-2), 23-37.

7. Cowan, N. (2008). What are the differences between long-term, short-term, and working memory?. *Progress in brain research, 169*, 323-338

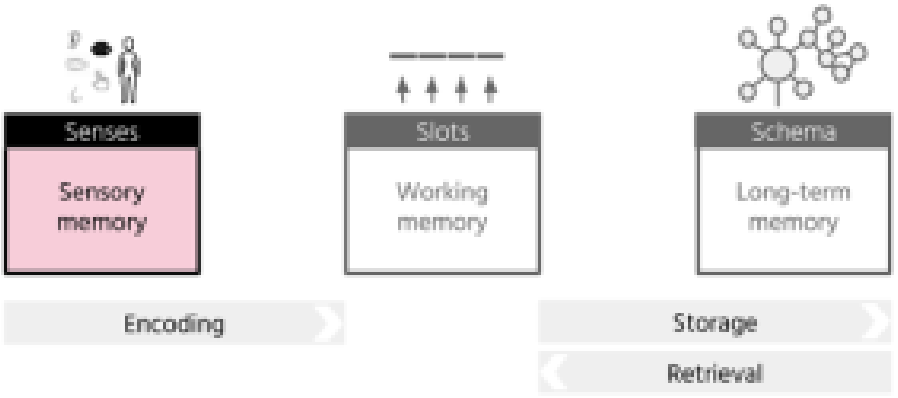

Figure 11.2 We collect information from our senses and encode it in short-term memory

Working Memory

Working memory "is short-term maintenance of information in the absence of sensory input" [8]. "Working memory includes short-term memory and other processing mechanisms that help to make use of short-term memory" [9]. In other words, working memory is a part of short-term memory and refers to the information held in STM that we are actively keeping and manipulating.

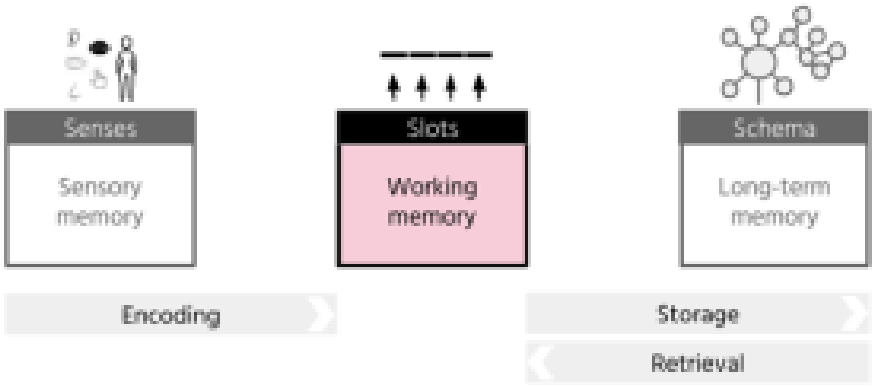

Figure 11.3 A depiction of working memory

8. Eriksson, J., Vogel, E. K., Lansner, A., Bergström, F., & Nyberg, L. (2015). Neurocognitive architecture of working memory. *Neuron, 88*(1), 33-46

9. Cowan, N. (2008).

Long-term Memory

Long-term memory (LTM) is "a vast store of knowledge and a record of prior events" [10]. "Long- and short-term memory could differ in two fundamental ways, with only short-term memory demonstrating (1) temporal decay and (2) chunk capacity limits" [11]. In other words, LTM does not decay as quickly as STM nor is there a clear limit to how much information can be stored in LTM (see Table 11.1. for a comparison of STM and LTM characteristics).

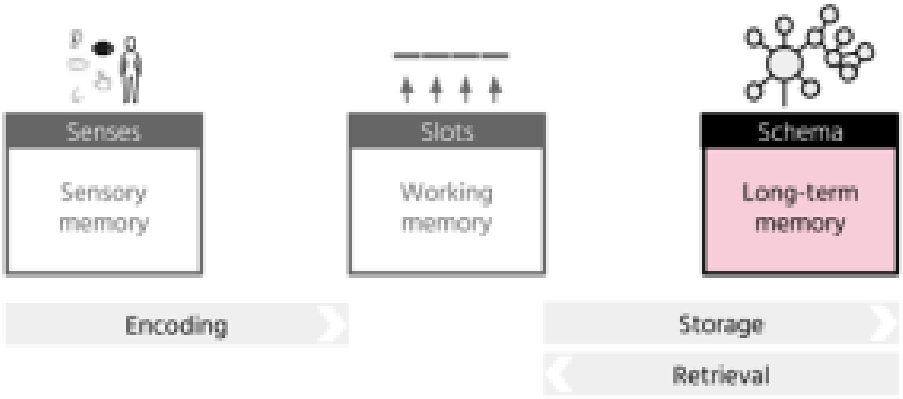

Figure 11.4 A depiction of long-term memory

How do we know short-term and long-term memory are distinct? Scientists can selectively block long-term or short-term memory formation without affecting the other [12]. For example, by blocking the receptors for neurotransmitters, STM can be disrupted, but LTM is still updated. Also, STM can form by interfering with protein synthesis, but LTM are not created or updated. The distinction in types of memory is also evidenced by the different types of amnesia [13]. "Anterograde amnesia is a loss of the ability to create new memories after the event that caused amnesia, leading to a partial or complete inability to recall the recent past, while long-term memories from before the event remain intact. This contrasts with retrograde amnesia, where memories created before the event are lost while new memories can still be created" [14].

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10. Cowan, N. (2008).

11. Cowan, N. (2008).

12. Cammarota, M., Bevilaqua, L. R., Medina, J. H., & Izquierdo, I. (2007). 10 Studies of Short-Term Avoidance Memory. *Neural plasticity and memory: from genes to brain imaging*, 193.

13. Squire, L. R., & Dede, A. J. (2015).

14. Anterograde amnesia. (n.d.). In Wikipedia. Retrieved May 15, 2020, from https://en.wikipedia.org/wiki/Anterograde_amnesia.

Table 11.1 Short-term memory and Long-term memory characteristics

Short-term (working) memory (STM) characteristics (Kukushkin & Carew, 2017; Eriksson et al., 2015; Kandel, Dudai, & Mayford, 2014)	Long-term memory (LTM) characteristics (Kukushkin & Carew, 2017; Eriksson et al., 2015; Kandel, Dudai, & Mayford, 2014)
• Duration: 10-15 s unless rehearsed • Capacity: 4 units or chunks of information • Formation (the speed at which they form): fast (milliseconds) • Region: prefrontal cortex – hippocampus • Mechanism: neurotransmitters	• Duration: from minutes to a lifetime • Capacity: no known limit • Formation (the speed at which they form): slow (minutes to days) • Region: neocortex (distributed across the neocortex) • Mechanism: new protein synthesis, gene expression

Critical Thinking

1. How does understanding the distinctions between sensory memory, working memory, and long-term memory help you make more informed teaching decisions?
2. Think about a time you couldn't remember something you recently learned—was it an issue of attention, rehearsal, or both?

The Purpose of STM and LTM

Why does our brain have distinct short-term and long-term memory systems? STM and LTM serve different purposes in our survival system [15]. Short-term memory enables us to rapidly adapt to novel experiences. As we live in a dynamic and uncertain environment and regularly encounter novel information, this is a critical ability. On the other hand, long-term memory enables us to effectively preadapt to future experiences. "The

15. Fuster, J. M., & Bressler, S. L. (2015). Past makes future: role of pFC in prediction. *Journal of cognitive neuroscience, 27*(4), 639-654.

biological utility of memory stems from its ability to modify future behavior based on past experience" [16]. We can identify patterns in our environment and improve the efficiency and effectiveness of our reactions [17].

Attention, Encoding, & Rehearsal

Sensory memory automatically gathers information from our senses, encoding it into a format the brain can interpret. Most of this information is ignored (e.g. unless we're eating, we don't pay much attention to the taste in our mouths). Encoding involves establishing temporary or short-term connections between new information and our prior knowledge networks (e.g. long-term memory). "Perceiving is remembering as much as sensing, and working memory is attention focused on an internal representation" [18]. Attention (what we focus on) is critical. If we don't pay attention to something, it does not get encoded. It doesn't enter our memory system so that we can consciously use the information. "The encoding of information into working memory is the result of interactions among selective attention processes and perceptual object representations that trigger related LTM object representations" [19].

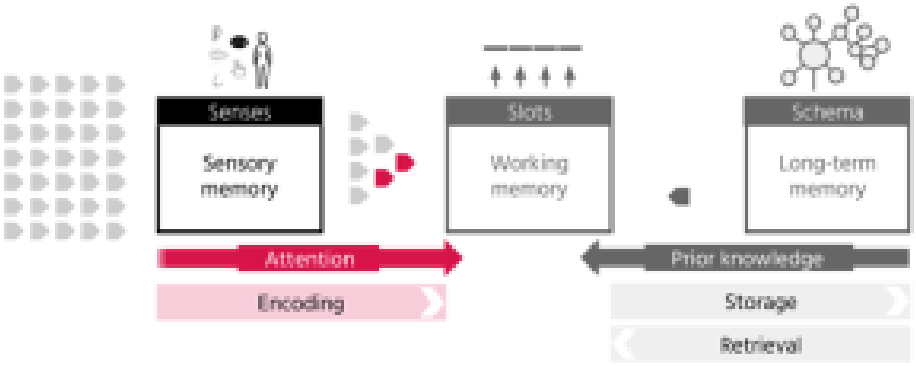

Figure 11.5 When we pay attention to information from our senses, that information is brought into working memory

The information that our attention falls on enters into short-term memory (STM) and is interpreted by our existing knowledge retrieved from long-term memory (LTM). This temporary connecting of information

16. Kukushkin, N. V., & Carew, T. J. (2017). Memory Takes Time. *Neuron, 95*(2), 259-279.

17. Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience, 8*(9), 657-661.

18. Fuster, J. M. (2009). Cortex and memory: emergence of a new paradigm. *Journal of cognitive neuroscience, 21*(11), 2047-2072.

19. Eriksson et al., 2015.

occurs in our working memory (WM) which is a part of STM and allows us to use or manipulate the information. "Information maintenance is considered to be the result of an interaction between basic building blocks of working memory, notably a selective attention process that operates on perceptual information and related long-term memory (LTM) representations" [20].

The information that is in our WM is what we are consciously aware of. However, WM is limited in capacity (i.e. studies have suggested between 4 to 9 slots) – so most of the information enters working memory temporarily and then leaves without being consolidated (e.g. stored) into LTM. Information that is used more (repeated) or has a high emotional value is prioritized for storage. In WM, our brain automatically retrieves our prior knowledge so that we can make these connections and try to make sense of the new information. This also means that anything new we learn, connects to something that is already there. "Storage of information is storage of relationships between objects or events" [21].

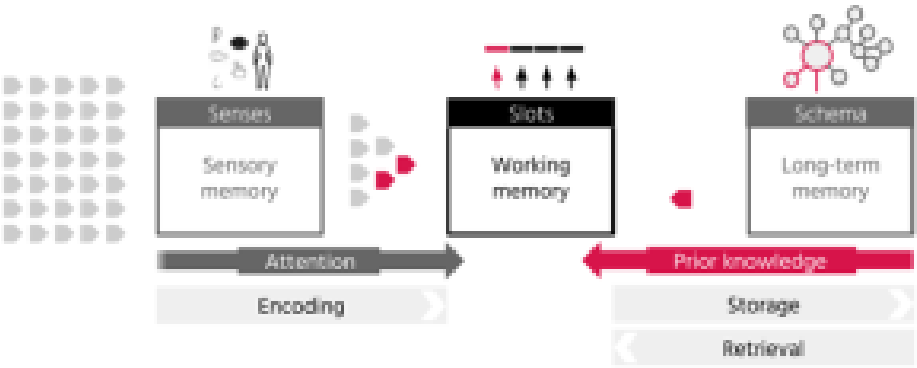

Figure 11.6 Encoding establishes temporary or short-term connections between new information and our prior knowledge

To maintain the temporary connections in working memory (STM), we have to rehearse (i.e. use or manipulate) the information which keeps it active. The more the information is used, the more likely it is to be prioritized for storage in LTM.

20. Eriksson et al., 2015.

21. Kukushkin & Carew, 2017.

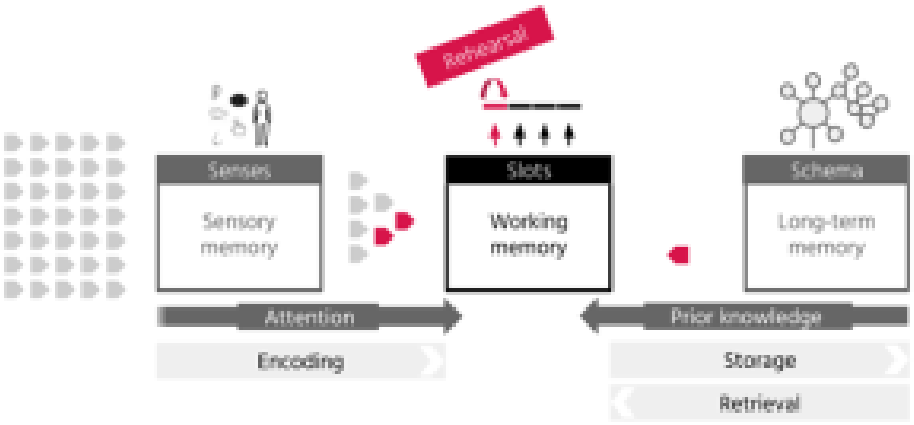

Figure 11.7 Rehearsing or using the information in working memory keeps the temporary connections active

To consolidate or store the information in long-term memory, the temporary connections need to be made more permanent. Hippocampal replay plays an important role. "Patterns of neuronal activity present during learning in the hippocampus are replayed during sleep" [22]. Replay can also occur during periods of wakeful rest. We don't have to sleep but we need to give our brains a break – an opportunity to repeat and consolidate information from recent experiences.

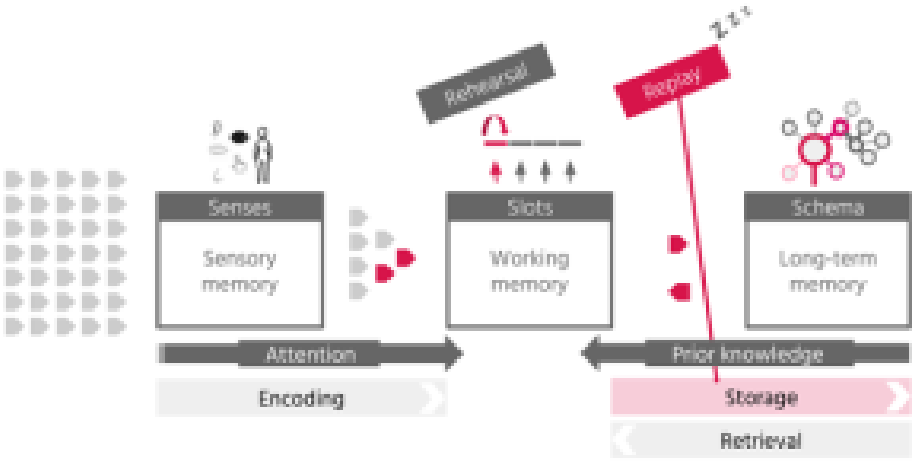

Figure 11.8 Hippocampal replay plays a role in making memories more permanent

To be retrievable in the future, information held in WM has to be consolidated into LTM. LTM consists of

22. Breton, J., & Robertson, E. M. (2013). Memory Processing: The critical role of neuronal replay during sleep. *Current Biology, 23*(18), R836-R838.

connected networks or schema which we activate when we recall or retrieve information. Cues associated with the stored LTM are used to determine when to retrieve the stored information. Once a memory is retrieved, it becomes active and will be reconsolidated or updated as it is stored once again. Reconsolidation reveals that long-term memories are not permanent but rather they are changed whenever they are activated. Most of the information that enters our memory system is lost. In other words, it does not remain in our memory system in a manner in which we can consciously retrieve it – at least not for an extended period of time.

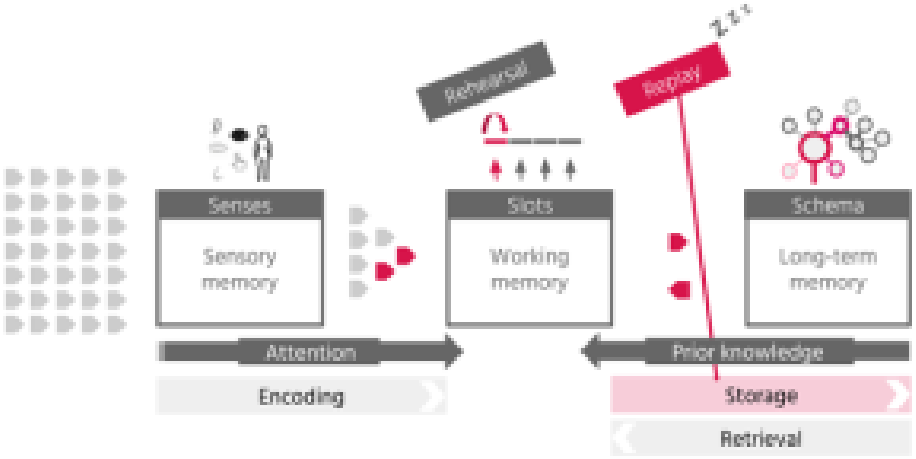

Figure 11.9 Cues are used to reactivate memories during retrieval

Critical Thinking

1. Which memory-supportive strategies (e.g., retrieval practice, chunking, connecting to prior knowledge) do you plan to incorporate into your own learning? Why?
2. Your teaching? teaching, and why?

Review & Practice

1. What are the three main types of memory in the cognitive model?
2. How does sensory memory differ from working memory?
3. What is the primary role of long-term memory in learning?
4. What is one key characteristic that distinguishes working memory from short-term memory?
5. Why is it important to connect new information to prior knowledge?
6. What role does attention play in memory encoding?
7. How does rehearsal help maintain information in working memory?
8. What happens to information that is not rehearsed or emotionally significant?
9. Why is rehearsal critical to consolidation?
10. What is meant by cognitive load?
11. Why do connections to prior knowledge improve learning?
12. How can retrieval practice strengthen memory?
13. How can teachers reduce unnecessary cognitive load in instruction?

External Links to Learning about Memory Processing

About Learning and Memory

1. Brains manage neurons like air traffic controllers manage airplane movements
2. Neuroscientists find memory cells that help us interpret new situations
3. Human memory: How we make, remember, and forget memories
4. The Brain Maps Out Ideas and Memories Like Spaces
5. MIT scientists discover fundamental rule of brain plasticity
6. How memories are formed and retrieved by the brain revealed in a new study

About Attention, Focus, and Perception

1. How anxiety affects your focus
2. Multitasking between devices is associated with poorer attention and memory
3. "Reality" is constructed by your brain. Here's what that means, and why it matters.
4. What you're seeing right now is the past, so your brain is predicting the present
5. The Brain Reshapes Our Malleable Senses to Fit the World
6. Science Explains Why Uncertainty Is So Hard on Our Brain
7. Magic is helping to unlock the mysteries of the human brain
8. How well you can identify colors, sounds, and tastes depends on where you come from
9. Why two people see the same thing but have different memories
10. "Hyperscans" Show How Brains Sync as People Interact

About learning and Teaching

1. Why procrastination is about managing emotions, not time
2. The Value of Mind Wandering in Solving Difficult Problems
3. 8 Great Ways to Enhance Retention
4. The Value of Tinkering
5. Using Brain Breaks to Restore Students' Focus

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CHAPTER 12: COGNITIVE VIEWS OF LEARNING: LEARNING FOR TRANSFER

Learning Objectives

1. Define transfer and explain why it is a key outcome of effective learning.
2. Differentiate between types of transfer (near, far, positive, negative, flexible).
3. Identify conditions that support learning transfer.
4. Describe classroom strategies that can promote meaningful, long-term transfer.

Introduction to Durable Learning and Transfer

We are teaching for some time in the future when the knowledge and skills that are learned in our classes are tested in contexts that we cannot know and with assessments that we cannot design. We need to provide an education that lasts a lifetime..." [1].

In the Science of Learning (SOL) literature, we often talk about three areas that greatly influence learning. Three interrelated areas: motivation, emotion, and cognition [2]. All are critical. In this course, we focus primarily on the cognitive aspects of learning—especially the concept of durable learning. Our goal is not only to help students succeed academically, but also to ensure they can apply what they've learned in meaningful ways beyond the classroom. This ability to use learning in new and real-world contexts is known as knowledge

1. Halpern, D. F., & Hakel, M. D. (2003). Applying the science of learning to the university and beyond: Teaching for long-term retention and transfer. *Change: The Magazine of Higher Learning, 35*(4), 36-41.

2. Ainley, M. (2006). Connecting with learning: Motivation, affect and cognition in interest processes. Educational Psychology Review, 18(4), 391-405.

transfer. This requires that they remember what they've learned beyond the tests they take. Unfortunately, many students forget much of what they've learned despite performing well on tests [3].

Striving for "learning that lasts a lifetime" involves teaching for long-term retention and transfer.

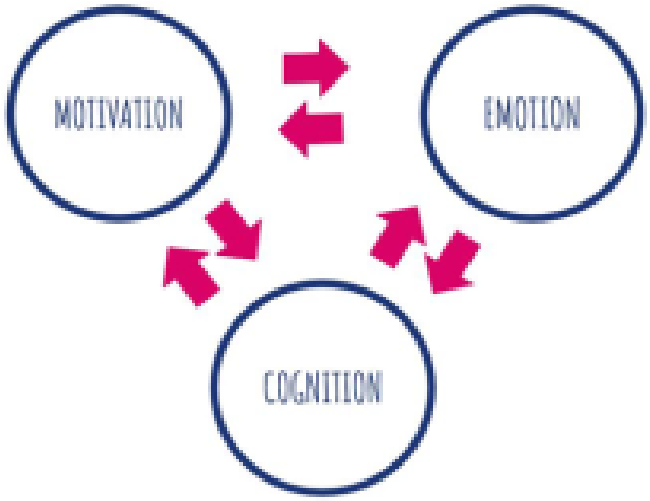

Figure 12.1 Interrelated processes that guide learning

Critical Thinking

1. Think of a time you did well on a test but quickly forgot the material. What made the learning short-lived?

What is Transfer?

Transfer is the ability to apply knowledge or skills learned in one context to a new or different situation. If knowledge doesn't transfer, it doesn't serve students beyond the classroom. Teaching for transfer is a hallmark of effective instruction because it reflects deep understanding and long-term usefulness of learning. Teachers

3. Bacon, D. R., & Stewart, K. A. (2006). How fast do students forget what they learn in consumer behavior? A longitudinal study. Journal of Marketing Education, 28(3), 181-192.

aim not only for students to perform well on a test but also for them to use what they've learned beyond the classroom—in other subjects, grade levels, and life experiences.

Types of Transfer

There are several different types of transfer, and recognizing the differences can help teachers better plan for meaningful learning. For purposes of this chapter, we focus only on the following four types:

- *Positive Transfer-* Learning a skill or concept in one context aides learning another concept (E.g. A student learns to sound out words in reading class and then uses that skill to figure out a new word while reading a storybook.)
- *Negative Transfer*– learning in one context that hinders learning in another context. (E.g. A student learns that adding an "s" makes a word plural (cat → cats) and then incorrectly says "mouses" instead of "mice."
- *Near Transfer*– learning that occurs when knowledge is applied in similar contexts. (E.g. A student who learns to manipulate equations in algebra may use that same skill to rearrange a speed formula in science class.)
- *Far transfer* involves applying learning in a context that is significantly different from the original one—such as using skills developed in a school project to solve a real-world problem outside of school. (E.g. Learning to identify evidence of learning during observations and then drawing on that knowledge as a teacher and asking students to explain their thinking on exit tickets)

Different kinds of learning experiences can look equivalent when tests of learning focus solely on remembering (e.g., on the ability to repeat previously taught facts or procedures), but they can look quite different when tests of transfer are used. Each type of transfer helps us understand not just whether learning occurred, but how deeply and meaningfully it can be used.

Critical Reflection

1. What are some personal examples of near/far transfer? Positive/negative/

How Transfer Works

Transfer doesn't just happen by chance. It depends on several key factors:

- Depth of understanding: Students are more likely to transfer what they learn when they grasp core concepts—not just facts or steps.
- Prior knowledge and schema: When students have well-developed mental frameworks (schemas), they can connect and apply new information more easily.
- Spaced and varied practice: Distributing learning over time and exposing students to concepts in multiple contexts strengthens memory and adaptability.
- Metacognition: Students who are aware of their own learning can better recognize when and how to apply what they know.
- Motivation and relevance: Transfer is more likely when students see learning as useful and connected to their goals or real life.

Classroom Strategies That Promote Transfer

As we've explored, true learning extends beyond temporary performance and into lasting, transferable knowledge—knowledge students can flexibly apply in unfamiliar or meaningful contexts. But such durable learning doesn't happen by accident. It is shaped by how we teach. This is where evidence-based teaching practices become essential. These practices—grounded in research about how the brain learns—are designed to maximize long-term retention and improve students' ability to apply learning in diverse settings.

To help students move from rote learning to transfer, teachers can:

- Use real-world examples and scenarios that mirror how knowledge is used outside of school.
- Prompt students to reflect on their thinking and how they might apply it elsewhere (metacognitive prompts).
- Revisit key concepts over time (spiral review or spaced learning).
- Design tasks that require students to apply knowledge in new formats or subjects.
- Scaffold learning so students practice adapting what they've learned.

Classroom Example

A teacher might teach persuasive writing techniques, then ask students to use them to write a speech, design a poster, and later reflect on how persuasion appears in advertising. This helps promote near and far transfer.

Ultimately, transfer is a sign of learning with understanding. When we teach with this in mind, we prepare students not just for tests—but for life.

Review & Practice

1. What is transfer, and why is it considered a central goal of teaching and learning?
2. Explain the difference between near transfer and far transfer, using your own example.
3. What role does prior knowledge and schema play in supporting transfer?
4. How does metacognition enhance a student's ability to transfer learning to new contexts?
5. Describe a classroom strategy that could help promote far transfer.
6. What are two conditions that make transfer more likely to occur?
7. How might a teacher design an activity that fosters both mastery and future transfer?

More Links to Learning about Teaching Processing

About Learning and Teaching Strategies

1. Tips for Teaching for Transfer: A BDA Approach
2. Retrieval Practice and Transfer of Learning
3. Helping Learners Develop METACOGNITION
4. Evidence-Based Teaching Practices

Media Attributions

- Interrelated processes that guide learning

CHAPTER 13: CONSTRUCTIVIST VIEWS OF LEARNING

What is Constructivism?

Constructivism is the philosophical and scientific position that knowledge arises through a process of active construction [1].

Learning Objectives

1. Explain the foundational principles of constructivism—including both cognitive and social perspectives.
2. Compare the roles of major theorists such as Piaget, Vygotsky, Dewey, and Bruner.
3. Apply constructivist principles to analyze and redesign classroom practices, including instructional strategies, learning environments, and assessment methods.

Introduction

Constructivism is a foundational learning theory that emphasizes how students actively build understanding, rather than passively receive information. Influenced by theorists like Piaget, Vygotsky, Dewey, and Bruner, it views learning as a dynamic, student-centered process shaped by prior knowledge, social interaction, and meaningful experiences. In constructivist classrooms, students engage in inquiry, dialogue, and real-world problem-solving to construct their own knowledge. Contrary to common assumptions, constructivism is relevant at all levels of learning and remains a powerful guide for classroom practice. As Brooks (1999) noted, "Constructivism, the study of learning, is about how we all make sense of our world, and that really

1. Mascolol & Fischer, 2005.

hasn't changed." This chapter will explore how constructivism—particularly cognitive and social constructivism—can help reframe how teachers understand and support student learning.

Cognitive & Social Constructivism

Cognitive Constructivism and Social Constructivism are two similar learning theories which share a large number of underlying assumptions:

Both Approaches	Social Constructivism
• Deep roots classical antiquity. Socrates, in dialogue with his followers, asked directed questions that led his students to realize for themselves the weaknesses in their thinking. • Learning is perceived as an active, not a passive, process, where knowledge is constructed, not acquired. • Knowledge construction is based on • personal experiences and the continual testing of hypotheses. • Each person has a different interpretation and construction of knowledge process, based on past experiences and cultural factors.	• Emphasis is on the collaborat • All cognitive functions are b interactions. • Learning is more than the ass learners were integrated into • Believed that constructivists and consequently failed to u

Underlying Assumptions

Jonassen (1994) proposed that there are eight characteristics that underlie the constructivist learning environments and are applicable to both perspectives:

- Constructivist learning environments provide multiple representations of reality.
- Multiple representations avoid oversimplification and represent the complexity of the real world.
- Constructivist learning environments emphasize knowledge construction instead of knowledge reproduction.
- Constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context.
- Constructivist learning environments provide learning environments such as real- world settings or case-based learning instead of predetermined sequences of instruction.
- Constructivist learning environments encourage thoughtful reflection on experience.
- Constructivist learning environments "enable context- and content- dependent knowledge construction."
- Constructivist learning environments support "collaborative construction of knowledge through social negotiation, not competition among learners for recognition."

According to constructivist's philosophy, there is no absolute knowledge, just our interpretation of it. The acquisition of knowledge therefore requires the individual to consider the information and – based on their past experiences, personal views, and cultural background – construct an interpretation of the information that is being presented to them.

Students 'construct' their own meaning by building on their previous knowledge and experience. New ideas and experiences are matched against existing knowledge, and the learner constructs new or adapted rules to make sense of the world. In such an environment the teacher cannot be in charge of the students' learning, since everyone's view of reality will be so different and students will come to learning already possessing their own constructs of the world.

Teaching styles based on this approach therefore mark a conscious effort to move from these 'traditional, objectivist models didactic, memory-oriented transmission models' (Cannella & Reiff, 1994) to a more student-centred approach.

Critical Thinking

How would you respond to the suggestion that Constructivism as a philosophical assumption applies only to more advanced levels of teaching and learning?

Main Constructivist Theorists

John Dewey (1933/1998) is often cited as the philosophical founder of this approach. **Bruner** (1990) and **Piaget** (1972) are considered the chief theorists among the cognitive constructivists, while **Vygotsky** (1978) is the major theorist among the social constructivists.

Dewey

John Dewey rejected the notion that schools should focus on repetitive, rote memorization & proposed a method of "directed living" – students would engage in real-world, practical workshops in which they would demonstrate their knowledge through creativity and collaboration. Students should be provided with opportunities to think from themselves and articulate their thoughts.

Dewey called for education to be grounded in real experience. He wrote, "If you have doubts about how learning happens, engage in sustained inquiry: study, ponder, consider alternative possibilities and arrive at your belief grounded in evidence."

Piaget

Piaget rejected the idea that learning was the passive assimilation of given knowledge. Instead, he proposed that learning is a dynamic process comprising successive stages of adaptation to reality during which learners actively construct knowledge by creating and testing their own theories of the world. Although less contemporary & influential, it has inspired several important educational principles such as:

- Discovery learning
- Sensitivity to children's' readiness
- Acceptance of individual differences
- Learners don't have knowledge forced on them – they create it for themselves

Bruner

Influenced by Vygotsky, Bruner emphasizes the role of the teacher, language and instruction. He thought that different processes were used by learners in problem solving, that these vary from person to person and that social interaction lay at the root of good learning.

Bruner builds on the Socratic tradition of learning through dialogue, encouraging the learner to come to enlighten themselves through reflection. Careful curriculum design is essential so that one area builds upon the other. Learning must therefore be a process of discovery where learners build their own knowledge, with the active dialogue of teachers, building on their existing knowledge. Bruner initiated curriculum change based on the notion that learning is an active, social process in which students construct new ideas or concepts based on their current knowledge. He provides the following principles of constructivistic learning:

- Instruction must be concerned with the experiences and contexts that make the student willing and able to learn (readiness).
- Instruction must be structured so that it can be easily grasped by the student (spiral organization).
- Instruction should be designed to facilitate extrapolation and or fill in the gaps (going beyond the information given).

Vygotsky

Social constructivism was developed by Vygotsky. He rejected the assumption made by Piaget that it was possible to separate learning from its social context.

According to Vygotsky:

> Every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the

formation of concepts. All the higher functions originate as actual relationships between individuals. (p. 57)

Although Vygotsky died at the age of 38 in 1934, most of his publications did not appear in English until after 1960. There are, however, a growing number of applications of social constructivism in the area of educational technology.

By the 1980s the research of Dewey and Vygotsky had blended with Piaget's work in developmental psychology into the broad approach of constructivism. The basic tenet of constructivism is that *students learn by doing rather than observing*. *Students bring prior knowledge into a learning situation in which they must critique and re-evaluate their understanding of it.*

Critical Thinking

Which of the four constructivist theorists—Piaget, Vygotsky, Dewey, or Bruner—do you most resonate with as a future teacher, and why? How might their ideas influence the way you design learning experiences or interact with students in your classroom?

Applying Constructivism Approaches in the Classroom

General Overview

In the constructivist classroom, the focus tends to shift from the teacher to the students. The classroom is no longer a place where the teacher ("expert") pours knowledge into passive students, who wait like empty vessels to be filled. In the constructivist model, the students are urged to be actively involved in their own process of learning.

In the constructivist classroom, both teacher and students think of knowledge as a dynamic, ever-changing view of the world we live in and the ability to successfully stretch and explore that view – not as inert factoids to be memorized.

Key assumptions of this perspective include:

1. What the student currently believes, whether correct or incorrect, is important.
2. Despite having the same learning experience, each individual will base their learning on the understanding and meaning personal to them.
3. Understanding or constructing a meaning is an active and continuous process.

4. Learning may involve some conceptual changes.
5. When students construct a new meaning, they may not believe it but may give it provisional acceptance or even rejection.
6. Learning is an active, not a passive, process and depends on the students taking responsibility to learn.

The main activity in a constructivist classroom is solving problems. Students use inquiry methods to ask questions, investigate a topic, and use a variety of resources to find solutions and answers. As students explore the topic, they draw conclusions, and, as exploration continues, they revisit those conclusions. Exploration of questions leads to more questions

There is a great deal of overlap between a constructivist and social constructivist classroom, with the exception of the greater emphasis placed on learning through social interaction, and the value placed on cultural background. For Vygotsky, culture gives the child the cognitive tools needed for development. Adults in the learner's environment are conduits for the tools of the culture, which include language, cultural history, social context, and more recently, electronic forms of information access.

In social constructivist classrooms collaborative learning is a process of peer interaction that is mediated and structured by the teacher. Discussion can be promoted by the presentation of specific concepts, problems or scenarios, and is guided by means of effectively directed questions, the introduction and clarification of concepts and information, and references to previously learned material.

Role of the Teacher	**Role of the Student**
Teachers act as a "guide on the side" (as opposed to "sage on the stage") providing students with opportunities to test the adequacy of their current understandings	Students play a more active role in

Critical Thinking

Think about one class you are currently enrolled in. Which elements of this class could you change to more closely align it with the constructivist perspective?

Social Constructivism in the Classroom: Learning Strategies

There are many ways to implement learning strategies that are aligned with cognitive and social constructivism. Below is such a list of strategies.

Reciprocal Teaching

A teacher and 2 to 4 students form a collaborative group and take turns leading dialogues on a topic. Within the dialogues, group members apply four cognitive strategies:

1. Questioning
2. Summarizing
3. Clarifying
4. Predicting

This creates a ZPD in which students gradually assume more responsibility for the material, and through collaboration, forge group expectations for high-level thinking, and acquire skills vital for learning and success in everyday life.

Cooperative Learning

Cooperative learning is an instructional approach where students work together in small groups to achieve shared learning goals, with each member responsible not only for their own learning but also for helping others learn.

Key Features of Cooperative Learning

Feature	**Description**
Positive interdependence	Students rely on one another to succ
Individual accountability	Each student is responsible for their p
Face-to-face interaction	Group members discuss, explain, and
Social skills	Collaboration requires explicit practi
Group processing	Groups reflect on how well they worl

Situated Learning

In situated learning, the core idea is that *Knowledge is not just something we acquire, but something we do in context* (Lave & Wenger, 1991). Learning is most effective when it is situated" in authentic, meaningful activity rather than abstract, decontextualized instruction.

Some common examples of situated learning in educational contexts include teaching internships, classroom observations and theory-practice reflections, fieldtrips, role playing, project-based learning, etc.

Anchored Instruction

Anchored instruction presents learning within a rich meaningful problem or story (the "anchor"). It is designed to engage students in active, situated learning by anchoring new knowledge to realistic, complex contexts.

Key Features of Anchored Instruction

Feature	Description
The Anchor	A narrative or situation (often a video o
Real-world context	The scenario mirrors authentic challeng
Student-centered	Students explore, discuss, and apply kn
Multiple perspectives	Problems often involve competing view
Interdisciplinary	Anchors often combine math, reading,

Alternative Assessments

Constructivists believe that assessment should be used as a tool to enhance both the student's learning and the teacher's understanding of student's progress. It should not be used as an accountability tool that serves to stress or demoralise students. Types of assessments aligned to perspective include reflective journals/portfolios, case studies, group-based projects, presentations (verbal or poster), debates, role playing etc.

Within social constructivism, particularly, there is greater scope for involving students in the entire process:

- Criteria & expectations- Use rubrics; provide exemplars
- Variety of methods (student choice)
- Feedback- Emphasize growth over scores

Brooks and Brooks (1993) state that rather than saying "No" when a student does not give the exact answer being sought, the constructivist teacher attempts to understand the student's current thinking about the

topic. Through nonjudgmental questioning, the teacher leads the student to construct new understanding and acquire new skills.

Critical Thinking

Choose one of the constructivist classroom strategies described (e.g., reciprocal teaching, cooperative learning, situated learning, or anchored instruction). In what ways does this strategy reflect constructivist principles, and how might it look in a classroom you hope to teach in? What challenges might you face in implementing it, and how could you address them?

Review & Practice

1. In your own words, define constructivism as a learning theory. How does it differ from more traditional models of instruction?
2. What is the Zone of Proximal Development (ZPD), and how does it relate to scaffolding in a constructivist classroom?
3. There are multiple examples of instructional strategies aligned with constructivism (e.g., reciprocal teaching, anchored instruction, cooperative learning). Describe an additional strategy based on your own learning experiences, and explain how it promotes student ownership of learning.
4. What are two characteristics of constructivist assessment practices, and how do they differ from traditional assessments?
5. Reflect on one class you've taken or observed. What change could you make to more closely align it with constructivist principles? Explain your reasoning.

A common misunderstanding regarding constructivism is that instructors should never tell students anything directly but, instead, should always allow them to construct knowledge for themselves. This is actually confusing a theory of pedagogy (teaching) with a theory of knowing. Constructivism assumes that all knowledge is constructed from the learner's previous knowledge, regardless of how one is taught. Thus, even listening to a lecture involves active attempts to construct new knowledge.

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Jordan, A., Carlile, O., & Stack, A. (2008). Approaches to learning: A guide for teachers.

McGraw-Hill, Open University Press: Berkshire.

Ormrod, J.E. (1995). Human Learning (2nd ed.). New Jersey, Prentice Hall.

Race, P. (2006) The Lecturer's Toolkit: A Practical Guide to Assessment, Learning and Teaching. Routledge

Ryder, M (2009) Instructional Design Models. Downloaded from http://carbon.cudenver.edu/~mryder/itc_data/idmodels.html on 30 March 2009)

Selected Resources

List of learning theories and how they apply to practice: http://tip.psychology.org/

List of models and good info on each: http://carbon.cudenver.edu/~mryder/itc_data/idmodels.html

Outline of learning theories: http://www.learning-theories.com/

PART V

UNIT FIVE: THEORY TO PRACTICE: TEACHING FOR LEARNING

CHAPTER 14: EVIDENCE-BASED TEACHING PRACTICES

Learning Objectives

1. Describe the rationale behind using evidence-based teaching practices.
2. Identify and explain the impact of retrieval learning, spaced learning, and distributed practice on student outcomes.
3. Apply evidence-based strategies to classroom scenarios to support student learning and metacognition.

Why Use *Evidence-Based Practices*?

"Teaching is facilitated or hampered by different strategies in learning" [1]. What students do, the strategies that they use, make a difference in how much learning takes place. However, students "often have a faulty mental model of how they learn and remember, making them prone to both misassessing and mismanaging their own learning" [2]. Students need help in improving their abilities to learn – and what teachers do, the strategies they use, makes a difference. "Learning is enhanced or impeded by different instructional strategies" [3]. Project Illuminated highlights a few selected evidence-based teaching practices in its materials and workshops. These strategies are inexpensive to use (time, resources, effort), align with the science of learning (e.g. our

1. Hascher, T. (2010). Learning and Emotion: perspectives for theory and research. *European Educational Research Journal, 9*(1), 13-28

2. Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual review of psychology, 64*, 417-444

3. Hascher (2010)

understanding of how learning happens), and contribute to developing student metacognitive skills [4]. Namely, these strategies both help students learn and can help correct ineffective study habits such as cramming, rereading, and inadequacy of practice. The primary strategies of focus in Illuminated are retrieval learning which involves having learners try to reconstruct what they've learned from their memories, distributed practice which involves spacing the reviews of learning over time, and spaced learning which involves repetition and active breaks during a learning session.

Why is it important that we choose evidence-based practices? Because teaching strategies make a difference!

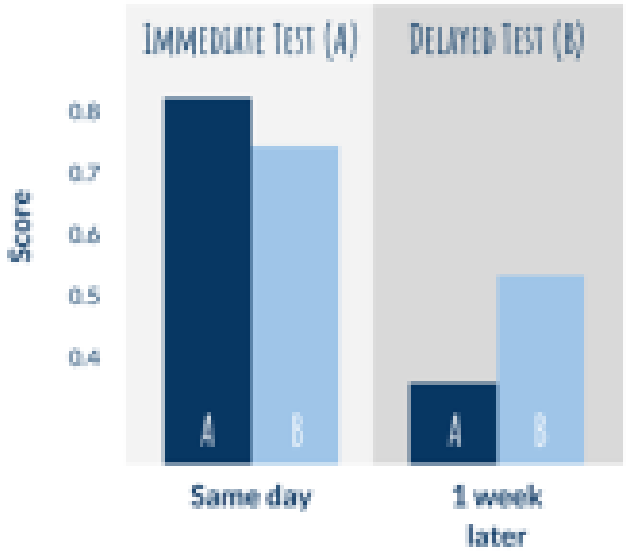

Figure 14.1 Studies often show that efficient learning strategies lead to longer lasting learning

The learning design decisions educators make impact student learning. Below are some examples taken from SOL empirical studies – studies that go beyond behavioral, observational, and learning assessment data and align their findings with our understanding of how the brain operates (i.e. consistent with our current understanding of the structural and functional properties of the brain). Note that the examples of retrieval learning, distributed practice and spaced learning are further elaborated on in the subsections that follow. Retrieval learning led to a 49% increase in test scores across students by changing the type of practice activities students performed (e.g. by having students practice "taking information out" rather than "putting

4. Pashler, H., Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., McDaniel, M., & Metcalfe, J. (2007). Organizing Instruction and Study to Improve Student Learning. IES Practice Guide. NCER 2007-2004. *National Center for Education Research*

information in") [5]. Distributed practice led to a 35% increase in student test scores. There was no increase in time spent learning, distributed practice just changed the schedule of when material was presented [6]. Spaced learning was shown to lead to a 14% increase in students' final test scores – this was achieved by changing how the content within a single lesson was presented [7]. Additional strategies have been integrated into the design of the Illuminated workshops including pause procedures which involve explaining what you've learned to a partner [8]; self-explanations which involve explaining what you've learned to yourself [9]; drawing to remember which involves representing key concepts visually and drawing them out to enhance learning [10]; and peer instruction which involves having students in lecture settings efficiently debate critical concepts [11]. All of these strategies are cheap to use. They don't require special technologies or applications, nor do they require additional classroom time [12].

Critical Thinking

1. As a future teacher, how will you balance your personal teaching style and instincts with the need to use strategies that are backed by research?
2. What challenges or benefits do you anticipate in making evidence-based decisions in your classroom?

5. Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*(6018), 772-775.

6. Bloom, K. C., & Shuell, T. J. (1981). Effects of massed and distributed practice on the learning and retention of second-language vocabulary. *The Journal of Educational Research, 74*(4), 245-248.

7. Kelley, P., & Whatson, T. (2013). Making long-term memories in minutes: a spaced learning pattern from memory research in education. *Frontiers in human neuroscience, 7,* 589.

8. Richards, L. W., Wang, A. T., Mahapatra, S., Jenkins, S. M., Collins, N. M., Beckman, T. J., & Wittich, C. M. (2017). Use of the pause procedure in continuing medical education: A randomized controlled intervention study. *Medical teacher, 39*(1), 74-78.

9. Bisra, K., Liu, Q., Nesbit, J. C., Salimi, F., & Winne, P. H. (2018). Inducing self-explanation: A meta-analysis.

10. Fernandes, M. A., Wammes, J. D., & Meade, M. E. (2018). The surprisingly powerful influence of drawing on memory. *Current Directions in Psychological Science, 27*(5), 302-308.

11. Mazur, E. (1997, March). Peer instruction: getting students to think in class. In *AIP Conference Proceedings* (Vol. 399, No. 1, pp. 981-988). AIP.

12. Pashler et al., 2007.

Spaced Learning

Previously, we introduced long-term potentiation (LTP) as a mechanism that makes the connections among brain cells more permanent. LTP is the process of synthesizing or creating proteins in the synapses (connections between brain cells) to make them more permanent. Previously, many believed that long-term memory formation took days or longer to form in humans. However, more recent research suggests that LTP can be triggered in a short period of time by a specific pattern of activation [13]. The pattern, much like a recipe, was three 'activations' separated by two 10-minute gaps. "New research into the neuroscience of learning has now identified how long-term memories can be made in minutes rather than days and for complex topics, not just basic associations" [14].

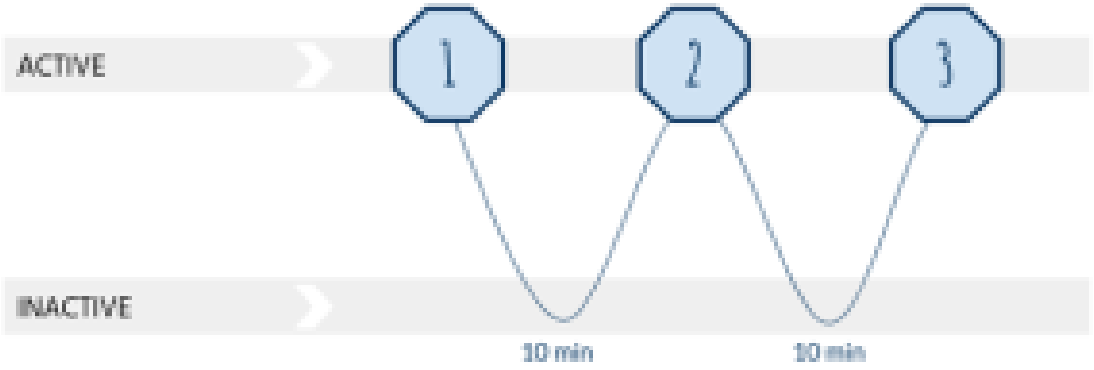

Figure 14.2 The Spaced Learning 'recipe' – three memory activations separated by two 10-minute breaks

What would happen if such a pattern was applied in a formal educational setting? Kelley and Whatson (2013) applied this recipe (and called Spaced Learning) in a study conducted with high school students (age 13-15) in the United Kingdom. Students were enrolled in a national curriculum biology course and were randomly assigned to one of three groups (N = 1700+). Group A completed 4 months of regular biology lessons (23 hrs of direct instruction). Their final lesson was a standard 1-hour review class. Group B completed a single, 1-hour lesson (1 hour of direct instruction). All the material for the course was condensed into the single lesson that followed the Spaced Learning pattern. Group C completed 4 months of regular biology lessons (23 hrs of

13. Fields, R. D. (2005). Making memories stick. *Scientific American, 292*(2), 74-81.

14. Ferguson, R., Barzilai, S., Ben-Zvi, D., Chinn, C.A., Herodotou, C., Hod, Y., Kali, Y., Kukulska-Hulme, A., Kupermintz, H., McAndrew, P., Rienties, B., Sagy, O., Scanlon, E., Sharples, M., Weller, M., & Whitelock, D. (2017). Innovating Pedagogy 2017: Open University Innovation Report 6. Milton Keynes: The Open University, UK.

direct instruction). Their final lesson was a Spaced Learning 1-hour review class. Five days after each group's review sessions, all students took a standardized national test on biology. What were the results of the study? Group B performed as well as Group A despite experiencing 22 fewer hours of instruction. Group B had 1 day instead of 4 months of study. Yet, Group C performed best of all. The class average increased by over 7 points just by modifying the design of the review class. So, if you teach courses, perhaps, consider spaced learning for the first and/or last lesson to better support students in forming LTM.

GROUP A	GROUP B
4 months of lessons	1 lesson
23 hrs of direct instruction	1 hr of direct instruction
1 hr of intensive review	All material in one lesson
Standardized national test *5 days after review session	Standardized national test *5 days after review session

Kelly & Whatson, 2013

Figure 14.3 The Spaced Learning study design

What could a Spaced Learning lesson look like? (1) The teacher presents key facts or information for 20-30 minutes. (2) Students are given a 10-minute active break. (3) Students review and recall the previously presented key facts/information. (4) Students are given a second 10-minute active break. (5) Students recall and apply the key facts/information. For the approach to work, it is believed that during the 10-minute breaks, the brain networks previously activated have to be inactive. Thus, rather than having a 'free' break, students complete a type of distractor activity. Something completely different that occupies their mind so they cannot go back to the previous learning. These activities could be drawing/pictionary, making models out of plaster, going for a walk in nature, etc.

Vigilance and Learning

When applying Spaced Learning we may want to choose a "fun" activity. According to the Yerkes-Dodson Law or inverted u-curve (see Figure 1), if our level of arousal (i.e. alertness) is too low we cannot perform (learn) well on challenging tasks. Moreover, if our level of arousal is too high (i.e. we are stressed) we cannot

perform (learn) well unless the task is simple. The ideal zone is in the middle [15]. However, sitting for a long time and listening, as many students do in classrooms, lowers our arousal levels. Physical movement, social activity, and a little fun works to increase arousal levels and can move us into a better zone for learning. Keeping the Yerkes-Dodson Law in mind can both help us select appropriate Spaced Learning break activities and also increase our awareness of the importance vigilance (or alertness) plays in learning. Vigilance, which relates to sustaining one's attention, is "influenced strongly by factors such as fatigue, anxiety, and motivation" [16]. Moreover, nutrition [17], physical fitness [18], and, critically, sleep [19] affect our abilities to reach optimal vigilance and can be considered basic ingredients of good learning.

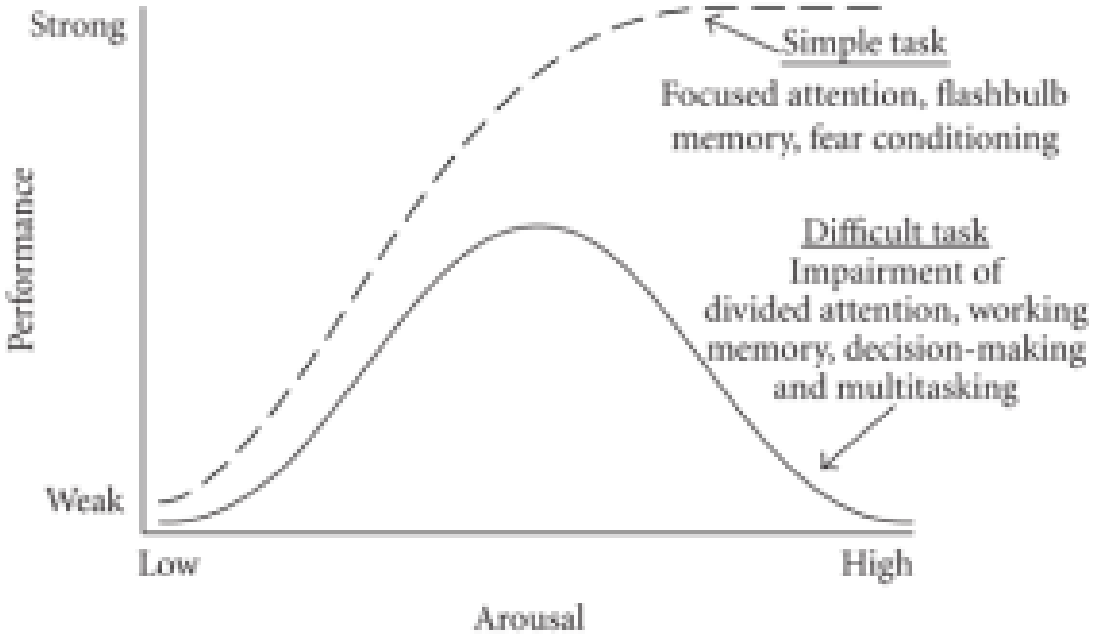

Figure 14.4 The Original Yerkes–Dodson law (Source: Wikipedia)

15. Sapolsky, R. M. (2015). Stress and the brain: individual variability and the inverted-U. *Nature neuroscience, 18*(10), 1344.

16. Abernethy, B., Maxwell, J. P., Masters, R. S., Van Der Kamp, J., & Jackson, R. C. (2007). Attentional processes in skill learning and expert performance. *Handbook of Sport Psychology, 3*, 245-263.

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18. de Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2018). Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of science and medicine in sport, 21*(5), 501-507.

19. Wright Jr, K. P., Hull, J. T., Hughes, R. J., Ronda, J. M., & Czeisler, C. A. (2006). Sleep and wakefulness out of phase with internal biological time impairs learning in humans. *Journal of Cognitive Neuroscience, 18*(4), 508-521.

Critical Thinking

Spaced learning improves retention, but it often requires breaking lessons into shorter, repeated segments over time.

1. How might you design instruction that uses spaced learning without losing student attention or disrupting engagement?
2. What strategies could help maintain alertness during repeated exposure to content?

Additional reading on rapid long-term memory formation

- Pastötter, B., & Bäuml, K. H. T. (2014). Retrieval practice enhances new learning: the forward effect of testing. *Frontiers in Psychology, 5*, 286.
- Antony, J. W., Ferreira, C. S., Norman, K. A., & Wimber, M. (2017). Retrieval as a fast route to memory consolidation. *Trends in cognitive sciences, 21*(8), 573-576.

Distributed Practice

Spacing Effect and Distributed Practice

How should learning be scheduled? The key concept to know is the spacing effect which describes "the robust finding that long-term learning is promoted when learning events are spaced out in time, rather than presented in immediate succession" [20]. The spacing effect has been demonstrated in hundreds of studies since 1885 including the learning of facts, concepts, language, science, pictures, prose, and skill and motor learning such as

20. Vlach, H. A., & Sandhofer, C. M. (2012). Distributing learning over time: The spacing effect in children's acquisition and generalization of science concepts. *Child development, 83*(4), 1137-1144.

typing, complex video games, and surgical skills [21]. Vlach and Sandhofer (2012) also found that the benefits of distributed practice are not limited to memory for specific information (e.g. facts or lists of words). Distributed practice also "promotes the acquisition and generalization of educational concepts." Distributed practice is the learning strategy that takes advantage of the spacing effect by deliberately spacing out learning over time. Below are two studies that demonstrate the benefits of distributed practice (i.e. the spacing effect).

Study 1: Massed vs. Distributed Practice

In the study by Rawson and Kintsch[22][/footnote] (2005), students read a long text and took two tests – immediately after the learning session and one week after the last learning session (e.g. the last time the students read the text). Group A read the text twice in a row (same day). Group B read the text twice with one week in between readings. Both groups spent the same amount of time reading the text. The massed group (Group A) performed better on the immediate test. The distributed group (Group B) performed much better on the delayed test. Often, the results of immediate tests can trick us into believing that massing practice or cramming, which is the student version of massed practice, is a more effective strategy.

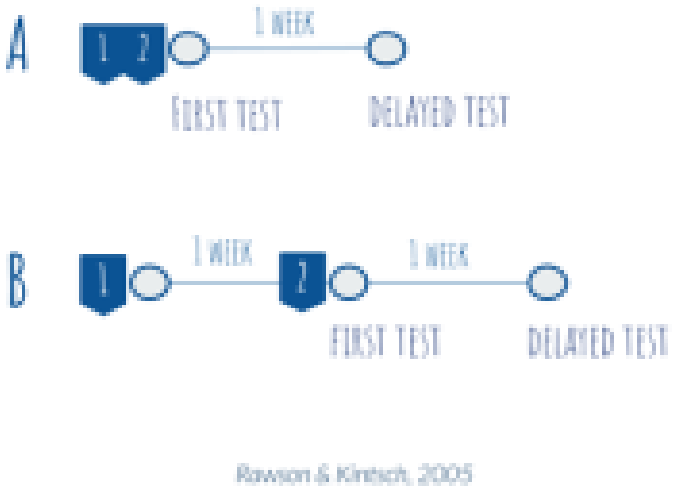

Figure 14.5 Visual representation of a distributed practice study design involving reading comprehension

21. Roediger III, H. L., & Pyc, M. A. (2012). Inexpensive techniques to improve education: Applying cognitive psychology to enhance educational practice. *Journal of Applied Research in Memory and Cognition, 1*(4), 242-248.

22. [23]Rawson, K. A., & Kintsch, W. (2005). Rereading effects depend on time of test. Journal of Educational Psychology, 97(1), 70.

23.

Study 2: Massed vs. Distributed Practice

High school students[24][/footnote] were taught French vocabulary and given a test 4 days later. Group A was taught in one 30-minute session. Group B was taught in three 10-minute sessions on successive days. There was a 35% advantage for distributed (Group B) over massed practice (Group A) – on the test taken 4 days later. This advantage was only due to changing how the learning was scheduled.

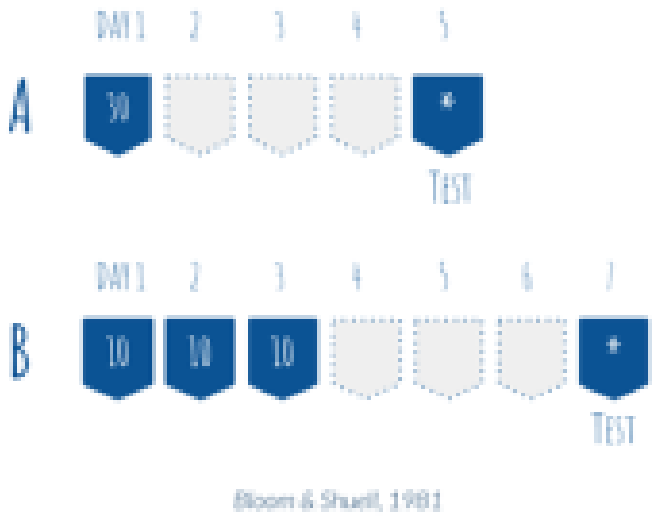

Figure 14.6 Visual representation of a distributed practice study design involving language learning

In sum, how we schedule learning activities matters. If we just want students to know the material for an exam, we can encourage massed practices. However, if we want them to keep what they've learned for a longer period of time then distributing their practice is critical. Moreover, it has been shown that "when retention intervals are measured at a week or greater, studies show that distributed practice nearly doubles recall performance [26]. " So, with a slight alteration to how we schedule the presentation of important content, independent of how students study on their own, we can both improve student rates of learning and model to students a fundamental lifelong learning strategy.

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24. [25]Bloom, K. C., & Shuell, T. J. (1981). Effects of massed and distributed practice on the learning and retention of second-language vocabulary. The Journal of Educational Research, 74(4), 245-248.
25.
26. Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological bulletin, 132*(3), 354.

Critical Thinking

1. How are spaced learning and distributed practice different?
2. Many students practice cramming over spaced-out reviews, even though research shows distributed practice leads to better long-term retention. As a future teacher, how will you design learning experiences or classroom routines that encourage distributed practice—and how will you help students value and adopt it?

Additional reading on the spacing effect and distributed practice

- Stahl, S. M., Davis, R. L., Kim, D. H., Lowe, N. G., Carlson, R. E., Fountain, K., & Grady, M. M. (2010). Play it again: The master psychopharmacology program as an example of interval learning in bite-sized portions. *CNS spectrums, 15*(8), 491-504.
- Bahrick, H. P. (1979). Maintenance of knowledge: Questions about memory we forgot to ask. *Journal of Experimental Psychology: General, 108*(3), 296.
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- Rawson, K. A., & Dunlosky, J. (2011). Optimizing schedules of retrieval practice for durable and efficient learning: How much is enough?. *Journal of Experimental Psychology: General, 140*(3), 283.
- Vlach, H. A., Sandhofer, C. M., & Bjork, R. A. (2014). Equal spacing and expanding schedules in children's categorization and generalization. *Journal of experimental child psychology, 123*, 129-137.
- Xue, G., Mei, L., Chen, C., Lu, Z. L., Poldrack, R., & Dong, Q. (2011). Spaced learning enhances subsequent recognition memory by reducing neural repetition suppression. *Journal of cognitive neuroscience, 23*(7).

Testing and Retrieval Learning

What type of activities have been shown to support durable learning in students? From a cognitive perspective, we can place learning activities into two broad categories: encoding activities and retrieval activities. Encoding related activities focus more on "putting information in" to long-term memory. Retrieval related activities focus more on "taking information out" of memory – i.e. practicing the extraction of information from our long-term memory. For example, when students listen to a teacher, read articles, watch videos, or create concept maps or write essays while looking at their notes, they perform encoding activities. These student actions are completed as part of putting information in memory accurately and elaborating on it. On the other hand, when students complete practice tests, write learning journals, instruct peers, or create concept maps or write essays from memory (e.g. without referring to their notes), they perform retrieval activities. As the student actions are completed without referring to their notes, they are required to retrieve the information from their memory system.

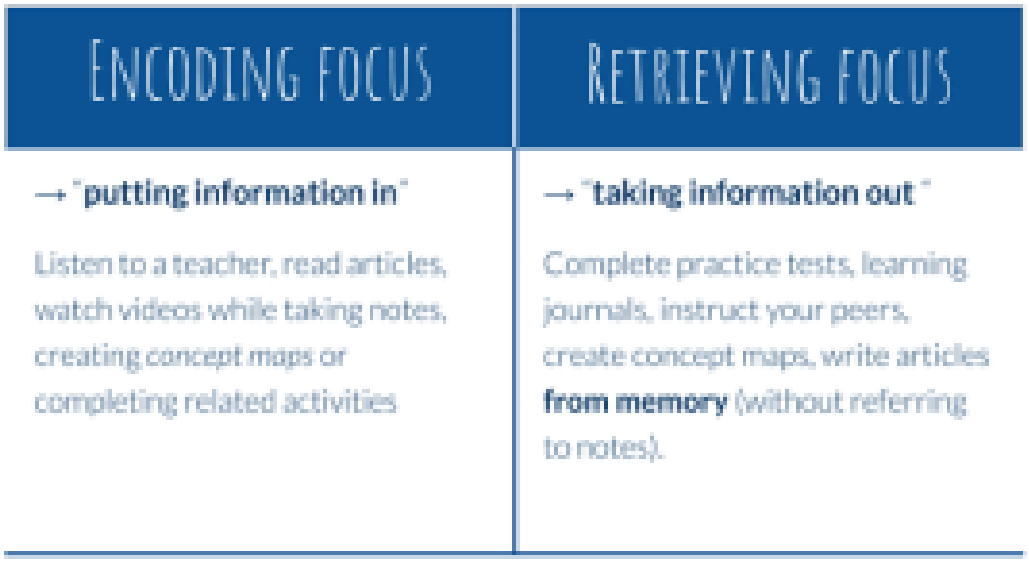

Figure 14.7 Common types of learning activities

Empirical studies have found that students need to reconstruct memories and strengthen retrieval routes. A mix of encoding and retrieval activities are beneficial. As Bjork, Dunlosky & Kornell (2013) write, "to be a sophisticated learner requires understanding that creating durable and flexible access to to-be-learned information is partly a matter of achieving a meaningful encoding of that information and partly a matter of exercising the retrieval process." But when comparing the efficacy of encoding versus retrieval types of activities, especially when reviewing material for tests, we see that retrieval activities are more effective in supporting durable learning. The results of such studies describe the testing effect. "Taking a test on material can have a greater positive effect on future retention of that material than spending an equivalent amount of

time restudying the material, even when performance on the test is far from perfect and no feedback is given on missed information" [27]. The testing effect has been demonstrated in hundreds of studies since 1909 including studies on language learning, general knowledge, visuospatial materials, science, social science, statistics and in medical education. The studies have used real university exams, online testing, and in-class testing [28]. Below are two studies that demonstrate the benefits of retrieval learning (i.e. the testing effect).

Study 1: Encoding vs. Retrieval Practice

Students studied two TOEFL texts[29][/footnote] and took three tests at different times. The first was an immediate test after the last learning session, the next was after a 2-day delay, and the third was after a 1-week delay. Group A studied the text four times (study-only). Group B studied the text once (7-min) and then took 3 free recall tests without feedback. In other words, the students in Group B read the text once and then wrote down all they could remember about the text 3 times without being able to see if their writing was correct or not. Both groups spent the same amount of time studying. The study-only group (Group A) performed better on the immediate test (81% vs. 75%). The retrieval group (Group B) performed better on delayed tests (56% vs. 42%). The benefits of retrieval activities became more apparent the longer the delay. "The repeated-testing condition recalled much more after a week than did students in the repeated-study condition (61% vs. 40%), even though students in the repeated-testing condition read the passage only 3.4 times and those in the repeated-study condition read it 14.2 times."

27. Roediger III, H. L., & Karpicke, J. D. (2006a). The power of testing memory: Basic research and implications for educational practice. *Perspectives on psychological science, 1*(3), 181-210.

28. Roediger III & Karpicke, 2006a

29. [30]Roediger III, H. L., & Karpicke, J. D. (2006b). Test-enhanced learning: Taking memory tests improves long-term retention. Psychological science, 17(3), 249-255.

30.

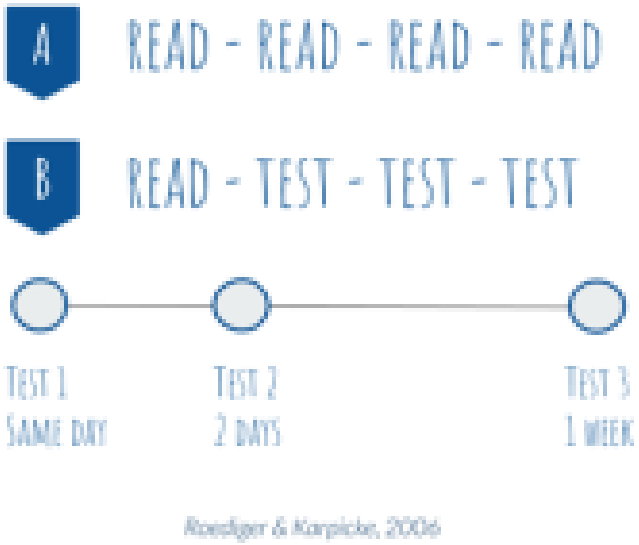

Figure 14.8 Visual representation of the retrieval learning study design

Study 2: Encoding vs. Retrieval Practice [31]

80 undergraduate students studied a science text and took a short-answer test (1 week later) with both verbatim and inference questions. Verbatim questions are recall questions of facts. Inference questions are more complex and require students to connect concepts within the text. Group A read the text and then created a concept map of the text. The concept map was created while reading the text. Group B read the text and wrote down all they could remember about the text (repeated twice) without referring to the text. There was almost a 50 percent increase for retrieval learning (M = 0.67) over concept mapping (M = 0.45) in conceptual learning in the test given a week later.

All in all, the type of learning activity we have students perform makes a difference. Interestingly, in Study 2 described above, even when the final test involved constructing a concept map, practicing retrieval during the original learning outperformed the group that practiced concept mapping [32].

31. Karpicke & Blunt, 2011.

32. Karpicke & Blunt, 2011.

Review & Practice

1. What is the difference between retrieval and encoding activities?
2. Why is distributed practice more effective than massed practice for long-term learning?
3. What are the stages of memory according to the multi-store model?

Additional reading on the testing effect and retrieval learning

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- Van den Broek, G., Takashima, A., Wiklund-Hörnqvist, C., Wirebring, L. K., Segers, E., Verhoeven, L., & Nyberg, L. (2016). Neurocognitive mechanisms of the "testing effect": A review. *Trends in Neuroscience and Education, 5*(2), 52-66.

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