Teaching Guide for GSIs

Learning: Theory and Research

Learning theory and research have long been the province of education and psychology, but what is now known about how people learn comes from research in many different disciplines. This chapter of the Teaching Guide introduces three central learning theories, as well as relevant research from the fields of neuroscience, anthropology, cognitive science, psychology, and education.

In This Section

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Overview of Learning Theories

Although there are many different approaches to learning, there are three basic types of learning theory: behaviorist, cognitive constructivist, and social constructivist. This section provides a brief introduction to each type of learning theory. The theories are treated in four parts: a short historical introduction, a discussion of the view of knowledge presupposed by the theory, an account of how the theory treats learning and student motivation, and finally, an overview of some of the instructional methods promoted by the theory is presented.

	Behaviorism	Cognitive Constructivism	Social Constructivism
View of knowledge	Knowledge is a repertoire of behavioral responses to environmental stimuli.	Knowledge systems of cognitive structures are actively constructed by learners based on pre-existing cognitive structures.	Knowledge is constructed within social contexts through interactions with a knowledge community.
View of learning	Passive absorption of a predefined body of knowledge by the learner. Promoted by repetition and positive reinforcement.	Active assimilation and accommodation of new information to existing cognitive structures. Discovery by learners.	Integration of students into a knowledge community. Collaborative assimilation and accommodation of new information.
View of motivation	Extrinsic, involving positive and negative reinforcement.	Intrinsic; learners set their own goals and motivate themselves to learn.	Intrinsic and extrinsic. Learning goals and motives are determined both by learners and extrinsic rewards provided by the knowledge community.
Implications for Teaching	Correct behavioral responses are transmitted by the teacher and absorbed by the students.	The teacher facilitates learning by providing an environment that promotes discovery and assimilation/accommodation.	Collaborative learning is facilitated and guided by the teacher. Group work.

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Behaviorism

> Behaviorist teaching methods have proven most successful in areas where there is a "correct" response or easily memorized material.

Background

Methodological behaviorism began as a reaction against the introspective psychology that dominated the late 19th and early 20th centuries. Introspective psychologists such as Wilhelm Wundt maintained that the study of consciousness was the primary object of psychology. Their methodology was primarily introspective, relying heavily on first-person reports of sensations and the constituents of immediate experiences. Behaviorists such as J. B. Watson and B. F. Skinner rejected introspectionist methods as being subjective and unquantifiable. Instead, they focused on objectively observable, quantifiable events and behavior. They argued that since it is not possible to observe objectively or to quantify what occurs in the mind, scientific theories should take into account only observable indicators such as stimulus-response sequences. According to Skinner (1976, 23),

> The mentalistic problem can be avoided by going directly to the prior physical causes while bypassing intermediate feelings or states of mind. The quickest way to do this is to … consider only those facts which can be objectively observed in the behavior of one person in its relation to his [or her] prior environmental history.

Radical behaviorists such as Skinner also made the ontological claim that facts about mental states are reducible to facts about behavioral dispositions.

View of Knowledge

Behaviorists such as Watson and Skinner construe knowledge as a repertoire of behaviors. Skinner argues that it is not the case that we use knowledge to guide our action; rather "knowledge is action, or at least rules for action" (152). It is a set of passive, largely mechanical responses to environmental stimuli. So, for instance, the behaviorist would argue that to say that that someone knows Shakespeare is to say that they have a certain behavioral repertoire with respect to Shakespeare (152). Knowledge that is not actively expressed in behavior can be explained as behavioral capacities. For example, "I know a bluebird when I see one" can be seen as effectively equivalent to "I have the capacity to identify a bluebird although I am not now doing so" (154). If knowledge is construed as a repertoire of behaviors, someone can be said to understand something if they possess the appropriate repertoire. No mention of cognitive processes is necessary (156–57).

View of Learning

From a behaviorist perspective, the transmission of information from teacher to learner is essentially the transmission of the response appropriate to a certain stimulus. Thus, the point of education is to present the student with the appropriate repertoire of behavioral responses to specific stimuli and to reinforce those responses through an effective reinforcement schedule (161). An effective reinforcement schedule

requires consistent repetition of the material; small, progressive sequences of tasks; and continuous positive reinforcement. Without positive reinforcement, learned responses will quickly become extinct. This is because learners will continue to modify their behavior until they receive some positive reinforcement.

View of Motivation

Behaviorists explain motivation in terms of schedules of positive and negative reinforcement. Just as receiving food pellets each time it pecks at a button teaches a pigeon to peck the button, pleasant experiences cause human learners to make the desired connections between specific stimuli and the appropriate responses. For example, a student who receives verbal praise and good grades for correct answers (positive reinforcement) is likely to learn those answers effectively; one who receives little or no positive feedback for the same answers (negative reinforcement) is less likely to learn them as effectively. Likewise, human learners tend to avoid responses that are associated with punishment or unpleasant consequences such as poor grades or adverse feedback.

Implications for Teaching

Behaviorist teaching methods tend to rely on so-called “skill and drill” exercises to provide the consistent repetition necessary for effective reinforcement of response patterns. Other methods include question (stimulus) and answer (response) frameworks in which questions are of gradually increasing difficulty; guided practice; and regular reviews of material. Behaviorist methods also typically rely heavily on the use of positive reinforcements such as verbal praise, good grades, and prizes. Behaviorists assess the degree of learning using methods that measure observable behavior such as exam performance. Behaviorist teaching methods have proven most successful in areas where there is a “correct” response or easily memorized material. For example, while behaviorist methods have proven to be successful in teaching structured material such as facts and formulae, scientific concepts, and foreign language vocabulary, their efficacy in teaching comprehension, composition, and analytical abilities is questionable.

Reference

Skinner, B. F. (1976). *About Behaviorism*. New York: Vintage Books.

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Cognitive Constructivism

> Cognitivist teaching methods aim to assist students in assimilating new information to existing knowledge, and enabling them to make the appropriate modifications to their existing intellectual framework to accommodate that information.

Background

Dissatisfaction with behaviorism's strict focus on observable behavior led educational psychologists such as Jean Piaget and William Perry to demand an approach to learning theory that paid more attention to what went on "inside the learner's head." They developed a cognitive approach that focused on mental processes rather than observable behavior. Common to most cognitivist approaches is the idea that knowledge comprises symbolic mental representations, such as propositions and images, together with a mechanism that operates on those representations. Knowledge is seen as something that is actively constructed by learners based on their existing cognitive structures. Therefore, learning is relative to their stage of cognitive development; understanding the learner's existing intellectual framework is central to understanding the learning process.

View of Knowledge

While behaviorists maintain that knowledge is a passively absorbed behavioral repertoire, cognitive constructivists argue instead that knowledge is actively constructed by learners and that any account of knowledge makes essential references to cognitive structures. Knowledge comprises active systems of intentional mental representations derived from past learning experiences. Each learner interprets experiences and information in the light of their extant knowledge, their stage of cognitive development, their cultural background, their personal history, and so forth. Learners use these factors to organize their experience and to select and transform new information. Knowledge is therefore actively constructed by the learner rather than passively absorbed; it is essentially dependent on the standpoint from which the learner approaches it.

View of Learning

Because knowledge is actively constructed, learning is presented as a process of active discovery. The role of the instructor is not to drill knowledge into students through consistent repetition, or to goad them into learning through carefully employed rewards and punishments. Rather, the role of the teacher is to facilitate discovery by providing the necessary resources and by guiding learners as they attempt to assimilate new knowledge to old and to modify the old to accommodate the new. Teachers must thus take into account the knowledge that the learner currently possesses when deciding how to construct the curriculum and to present, sequence, and structure new material.

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View of Motivation

Unlike behaviorist learning theory, where learners are thought to be motivated by extrinsic factors such as rewards and punishment, cognitive learning theory sees motivation as largely intrinsic. Because it involves significant restructuring of existing cognitive structures, successful learning requires a major personal investment on the part of the learner (Perry 1999, 54). Learners must face up to the limitations of their existing knowledge and accept the need to modify or abandon existing beliefs. Without some kind of internal drive on the part of the learner to do so, external rewards and punishments such as grades are unlikely to be sufficient.

Implications for Teaching

Cognitivist teaching methods aim to assist students in assimilating new information to existing knowledge, and enabling them to make the appropriate modifications to their existing intellectual framework to accommodate that information. Thus, while cognitivists allow for the use of "skill and drill" exercises in the memorization of facts, formulae, and lists, they place greater importance on strategies that help students to actively assimilate and accommodate new material. For instance, asking students to explain new material in their own words can assist them in assimilating it by forcing them to re-express the new ideas in their existing vocabulary. Likewise, providing students with sets of questions to structure their reading makes it easier for them to relate it to previous material by highlighting certain parts and to accommodate the new material by providing a clear organizational structure. Because learning is largely self-motivated in the cognitivist framework, cognitivists such as A. L. Brown and J. D. Ferrara have also suggested methods which require students to monitor their own learning. For instance, the use of ungraded tests and study questions enables students to monitor their own understanding of the material. Other methods that have been suggested include the use of learning journals by students to monitor progress and highlight any recurring difficulties, and to analyze study habits.

Jean Piaget

The most influential exponent of cognitivism was Swiss child psychologist Jean 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 adaption to reality during which learners actively construct knowledge by creating and testing their own theories of the world (1968, 8). Piaget's theory has two main strands: first, an account of the mechanisms by which cognitive development takes place; and second, an account of the four main stages of cognitive development through which children pass.

The basic principle underlying Piaget's theory is the principle of equilibration: all cognitive development (including both intellectual and affective development) progresses towards increasingly complex and stable levels of organization. Equilibration takes place through a process of adaption, that is, assimilation of new information to existing cognitive structures and the accommodation of that information through the formation of new cognitive structures. For example, learners who already have the cognitive structures necessary to solve percentage problems in mathematics will have some of the structures necessary to solve time-rate-distance problems, but they will need to modify their existing structures to accommodate the newly acquired information to solve the new type of problem. Thus, learners adapt and develop by assimilating and accommodating new information into existing cognitive structures.

Piaget suggested that there are four main stages in the cognitive development of children. In the first two years, children pass through a sensorimotor stage during which they progress from cognitive structures dominated by instinctual drives and undifferentiated emotions to more organized systems of concrete concepts, differentiated emotions, and their first external affective fixations. At this stage, children's

outlook is essentially egocentric in the sense that they are unable to take into account others' points of view. The second stage of development lasts until around seven years of age. Children begin to use language to make sense of reality. They learn to classify objects using different criteria and to manipulate numbers. Children's increasing linguistic skills open the way for greater socialization of action and communication with others. From the ages of seven to twelve years, children begin to develop logic, although they can only perform logical operations on concrete objects and events. In adolescence, children enter the formal operational stage, which continues throughout the rest of their lives. Children develop the ability to perform abstract intellectual operations, and reach affective and intellectual maturity. They learn how to formulate and test abstract hypotheses without referring to concrete objects. Most importantly, children develop the capacity to appreciate others' points of view as well as their own.

Piaget's theory was widely accepted from the 1950s until the 1970s. Although the theory is not now as widely accepted, it has had a significant influence on later theories of cognitive development. For instance, the idea of adaption through assimilation and accommodation is still widely accepted.

William G. Perry

William G. Perry, an educational researcher at Harvard University, developed an account of the cognitive and intellectual development of college-age students through a fifteen-year study of students at Harvard and Radcliffe in the 1950s and 1960s. Perry generalized that study to give a more detailed account of post-adolescent development than did Piaget. He also introduces the concept of positionality and develops a less static view of developmental transitions.

The sequence of cognitive structures that make up the developmental process may be described in terms of cross-sections of cognitive structures representative of different stages in the developmental sequence. Each stage is construed as a relatively stable, enduring cognitive structure, which includes and builds upon past structures. Stages are characterized by the coherence and consistency of the structures that compose them. The transition between stages is mediated by less stable, less consistent transitional structures. Freud, Whitehead, and Piaget all use the notion of a stage in this way. Perry rejects the notion of a stage. He argues that construing development in terms of a sequence of stable stages in which students are "imprisoned" is too static (Perry 1999, xii). Instead, he introduces the notion of a position. Perry accepted Piaget's claim that learners adapt and develop by assimilating and accommodating new information into existing cognitive structures. He also accepted Piaget's claim that the sequence of cognitive structures that constitute the developmental process are both logically and hierarchically related, insofar as each builds upon and thus presupposes the previous structure. However, he laid far greater emphasis on the idea that learners approach knowledge from a variety of different standpoints. Thus, according to Perry, gender, race, culture, and socioeconomic class influence our approach to learning just as much as our stage of cognitive development (xii). We each interpret the world from a different position (46) and each person may occupy several positions simultaneously with respect to different subjects and experiences (xii). The developmental process is a constantly changing series of transitions between various positions.

Perry provides the following illustration different types of position (1999, 2):

> … a lecturer announces that today he will consider three theories explanatory of _____.
> **Student A** has always taken it for granted that knowledge consists of correct answers, that there is one right answer per problem, and that teachers explain these answers for students to learn. He therefore listens for the lecturer to state which theory to learn.
> **Student B** makes the same general assumptions but with an elaboration to the effect that teachers sometimes present problems and procedures, rather than answers, "so that we can learn to find the right answer on our own…"

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> **Student C** assumes that an answer can be called "right" only in the light of its context, and that contexts or "frames of reference" differ…
> Whatever the lecturer then proceeds to do…, these three students will make meaning of the experience in different ways which will involve different assessments of their own choices and responsibilities.

Perry identifies nine basic positions, of which the three major positions are duality, multiplicity, and commitment.

- The most basic position is **duality**. The world, knowledge and morality are assumed to have a dualistic structure. Things are right or wrong, true or false, good or bad. Students see teachers as authority figures who impart right answers and "the truth." The role of the student is seen as being to receive those answers and demonstrate that they have learned them. Detachment is difficult in this because there is only a single, correct point of view. Most students have passed beyond this stage by the time that they arrive in university. Those who have not quickly do so in the inherently pluralistic culture of modern universities.
- Positions two through four are largely **transitional**. Learners gradually develop an increased recognition of multiplicity but still assimilate that multiplicity to the fundamentally dualistic framework of the first position. For instance, a student may recognize the existence of a multiplicity of different points of view in the university but still look for the point of view that the teacher "wants us to learn" (121).
- The next major position is **multiplicity**. The world, knowledge and morality are accepted as relativistic in the sense that truth is seen as relative to a frame of reference rather than absolute. Learners recognize that things can only be said to be right or wrong within a specific context. Teachers are seen as expert guides or consultants rather than as authority figures who impart "the truth." Peers are accepted as legitimate sources of learning (xxxii). This position involves a much more extensive restructuring of the learner's existing knowledge than previous positions as knowledge can no longer be assimilated to the existing dualistic organizational scheme.
- Positions six through eight are also largely **transitional**. Recognition of the relativity of knowledge leads to the realization that a stable locus or point of view is necessary for a sense of identity and to give some feeling of continuity. This leads to the gradual formation of commitments to certain points of view, relationships, sorts of activities, etc. The learner realizes the necessity to find his own point of view in a relativistic world. He or she begins by questioning and reconsidering past beliefs and commitments, then develops and expands upon firm commitments regarding important areas of life and knowledge.
- The final major position is **commitment**. The commitments that the learners have developed together with their recognition that all knowledge is relative, leads to the realization both that each person partly determines his or her own fate and the recognition that commitments, and hence identity, are constantly evolving.

Because Perry's initial research was based on a small and fairly non-representative sample of students, many of the details of his positions have been modified or developed by later researchers. However, the idea of positionality has had a significant influence on social identity theory and his account of developmental transitions is consonant with current approaches to adult learning (xii).

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References

Perry, William G. (1999). *Forms of Ethical and Intellectual Development in the College Years*. San Francisco: Jossey-Bass Publishers.

Piaget, Jean (1968). *Six Psychological Studies*. Anita Tenzer (Trans.), New York: Vintage Books.

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Social Constructivism

> The level of potential development is the level at which learning takes place. It comprises cognitive structures that are still in the process of maturing, but which can only mature under the guidance of or in collaboration with others.

Background

Social constructivism is a variety of cognitive constructivism that emphasizes the collaborative nature of much learning. Social constructivism was developed by post-revolutionary Soviet psychologist Lev Vygotsky. Vygotsky was a cognitivist, but rejected the assumption made by cognitivists such as Piaget and Perry that it was possible to separate learning from its social context. He argued that all cognitive functions originate in, and must therefore be explained as products of social interactions and that learning was not simply the assimilation and accommodation of new knowledge by learners; it was the process by which learners were integrated into a knowledge community. According to Vygotsky (1978, 57),

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.Vygotsky's theory of social learning has been expanded upon by numerous later theorists and researchers.

View of Knowledge

Cognitivists such as Piaget and Perry see knowledge as actively constructed by learners in response to interactions with environmental stimuli. Vygotsky emphasized the role of language and culture in cognitive development. According to Vygotsky, language and culture play essential roles both in human intellectual development and in how humans perceive the world. Humans' linguistic abilities enable them to overcome the natural limitations of their perceptual field by imposing culturally defined sense and meaning on the world. Language and culture are the frameworks through which humans experience, communicate, and understand reality. Vygotsky states (1968, 39),

A special feature of human perception … is the perception of real objects … I do not see the world simply in color and shape but also as a world with sense and meaning. I do not merely see something round and black with two hands; I see a clock …

Language and the conceptual schemes that are transmitted by means of language are essentially social phenomena. As a result, human cognitive structures are, Vygotsky believed, essentially socially constructed. Knowledge is not simply constructed, it is co-constructed.

View of Learning

Vygotsky accepted Piaget's claim that learners respond not to external stimuli but to their interpretation of those stimuli. However, he argued that cognitivists such as Piaget had overlooked the essentially social

nature of language. As a result, he claimed they had failed to understand that learning is a collaborative process. Vygotsky distinguished between two developmental levels (85):

The level of **actual** development is the level of development that the learner has already reached, and is the level at which the learner is capable of solving problems independently. The level of **potential** development (the "zone of proximal development") is the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers. The learner is capable of solving problems and understanding material at this level that they are not capable of solving or understanding at their level of actual development; the level of potential development is the level at which learning takes place. It comprises cognitive structures that are still in the process of maturing, but which can only mature under the guidance of or in collaboration with others.

View of Motivation

Behavioral motivation is essentially extrinsic — a reaction to positive and negative reinforcements. Cognitive motivation is essentially intrinsic — based on the learner's internal drive. Social constructivists see motivation as both extrinsic and intrinsic. Because learning is essentially a social phenomenon, learners are partially motivated by rewards provided by the knowledge community. However, because knowledge is actively constructed by the learner, learning also depends to a significant extent on the learner's internal drive to understand and promote the learning process.

Implications for Teaching

Collaborative learning methods require learners to develop teamwork skills and to see individual learning as essentially related to the success of group learning. The optimal size for group learning is four or five people. Since the average section size is ten to fifteen people, collaborative learning methods often require GSIs to break students into smaller groups, although discussion sections are essentially collaborative learning environments. For instance, in group investigations, students may be split into groups that are then required to choose and research a topic from a limited area. They are then held responsible for researching the topic and presenting their findings to the class. More generally, collaborative learning should be seen as 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; it is guided by means of effectively directed questions, the introduction and clarification of concepts and information, and references to previously learned material. Some more specific techniques are suggested in the Teaching Guide pages on Discussion Sections.

Reference

Vygotsky, Lev (1978). *Mind in Society*. London: Harvard University Press.

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Neuroscience and How Students Learn

This article is based on a talk by Daniela Kaufer, associate professor in the Integrative Biology department, for the GSI Center's How Students Learn series in Spring 2011.

On this page:

Also available:
Video and full summary of the talk "What can Neuroscience Research Teach Us about Teaching?"

Key learning principles

- From the point of view of neurobiology, learning involves changing the brain.
- Moderate stress is beneficial for learning, while mild and extreme stress are detrimental to learning.
- Adequate sleep, nutrition, and exercise encourage robust learning.
- Active learning takes advantage of processes that stimulate multiple neural connections in the brain and promote memory.

Neuroscience fundamentals

Changing the brain: For optimal learning to occur, the brain needs conditions under which it is able to change in response to stimuli (neuroplasticity) and able to produce new neurons (neurogenesis).

The most effective learning involves recruiting multiple regions of the brain for the learning task. These regions are associated with such functions as memory, the various senses, volitional control, and higher levels of cognitive functioning.

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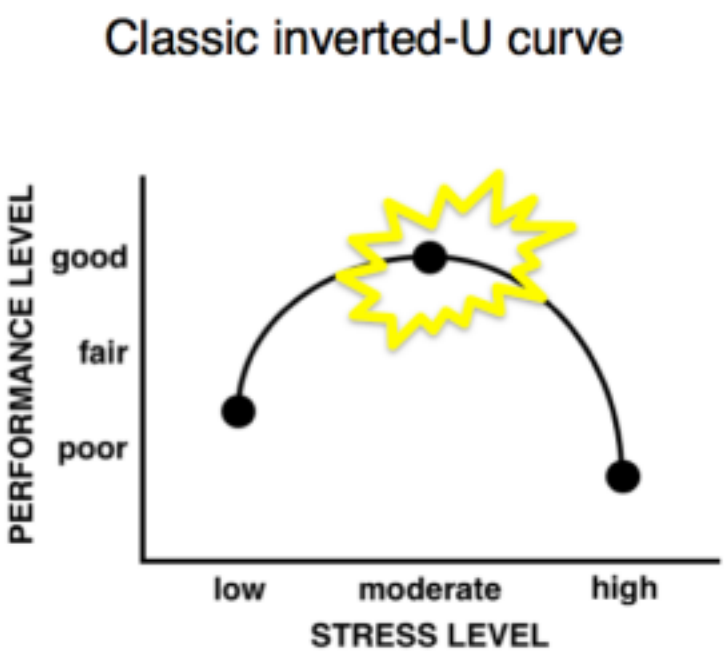

Moderate stress: Stress and performance are related in an "inverted U curve" (see right). Stimulation to learn requires a moderate amount of stress (measured in the level of cortisol). A low degree of stress is associated with low performance, as is high stress, which can set the system into fight-or-flight mode so there is less brain activity in the cortical areas where higher-level learning happens. Moderate levels of cortisol tend to correlate with the highest performance on tasks of any type. We can therefore conclude that moderate stress is beneficial for learning, while mild and extreme stress are both detrimental to learning.

Moderate stress can be introduced in many ways: by playing unfamiliar music before class, for example, or changing up the format of discussion, or any learning activity that requires individual participation or movement. However, people do not all react the same way to an event. The production of cortisol in response to an event varies significantly between individuals; what constitutes "moderate stress" for one person might constitute mild or extreme stress for another. So, for example, cold-calling on individual students in a large-group setting might introduce just the right amount of stress to increase some students' performance, but it might produce excessive stress and anxiety for other students, so their performance is below the level you know they are capable of. Any group dynamic that tends to stereotype or exclude some students also adds stress for them.

Adequate sleep, good nutrition, and regular exercise: These common-sense healthy habits promote optimal learning performance in two ways. First, they promote neuroplasticity and neurogenesis. Second, they keep cortisol and dopamine (stress and happiness hormones, respectively) at appropriate levels. All-night cramming sessions, skipped meals, and skipped exercise can actually reduce the brain's capacity for high academic performance. (This is true for instructors as well as students.)

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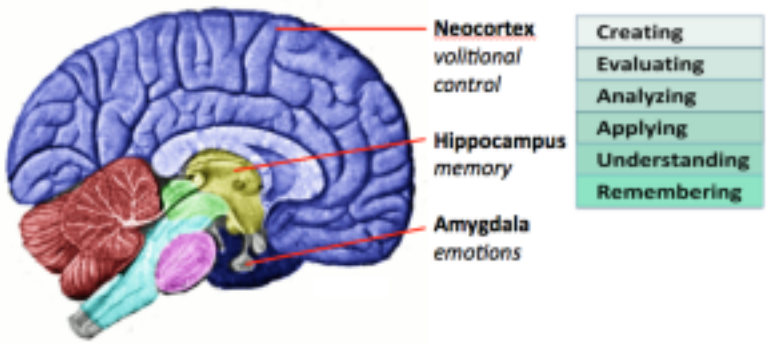

Bloom's taxonomy, which describes cognitive tasks in ascending orders of complexity, appears to be supported by neuroscience research. Recruiting volitional control, memory, and emotions through active learning techniques increases performance.

Brain image by Looie496 (Public domain), via Wikimedia Commons.
Verbs from Bloom's Revised Taxonomy of Learning Objectives in the Cognitive Domain, in Anderson, L. W. and David R. Krathwohl, D. R., et al. eds. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Boston: Allyn & Bacon, 2001.

Active learning: Cognitive functions associated with the lower levels of Bloom's taxonomy (see diagram at left) such as understanding and remembering, are associated with the hippocampus (the area of the brain responsible for memory and spatial awareness). The higher-level cognitive functions of Bloom's taxonomy, such as creating, evaluating, analyzing, and applying, involve the cortical areas responsible for decision-making, association, and motivation.

More complex thought processes are more beneficial for learning because they involve a greater number of neural connections and more neurological cross-talk. Active learning takes advantage of this cross-talk, stimulating a variety of areas of the brain and promoting memory.

Applications to Teaching

Active Learning Techniques from the Teaching Guide for GSIs

Some Basic Active Learning Strategies from the University of Minnesota Center for Teaching and Learning

Further Reading

Please note that some links may require Library proxy access. Please see the Library's page Connecting from Off Campus.

Blakemore, Sarah-Jayne and Uta Frith (2005). *The Learning Brain: Lessons for Education*. Malden, MA: Blackwell.

Felder, Richard M. and Rebecca Brent(1996). "Navigating the Bumpy Road to Student-Centered Instruction." An abridged version of this article was published in *College Teaching* 44: 43–47.

Tokuhama-Espinosa, Tracey (2011). *Mind, Brain, and Education Science: A Comprehensive Guide to the New Brain-Based Teaching*. New York: W. W. Norton.

Walker, J. D., et al. (2008). "A Delicate Balance: Integrating Active Learning Into a Large Lecture Course." *CBE Life Sciences Education* 7.4: 361–367.

Winter, Dale, et al. (2001). "Novice Instructors and Student-Centered Instruction: Identifying and Addressing Obstacles to Learning in the College Science Laboratory." *The Journal of Scholarship of Teaching and Learning* 2.1: 14–42.

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Cognitive Science: Memory and Learning

This article is based on presentations by Arthur Shimamura and John Kihlstrom, professors in the Department of Psychology, for the GSI Center's How Students Learn series in Spring 2011.

On this page:

Also available:
Video and full summary of Art Shimamura's talk "Active Learning AND Testing: The Key to Long-Lasting Memories"
Video and full summary of John Kihlstrom's talk "How Students Learn: A Perspective from Cognitive and Social Psychology"

Key Learning Principles

- Students learn best when they take control of and organize their new knowledge.
- Learning improves when new information is made meaningful for students.
- Repetition and simple mnemonic study techniques can be extremely effective.
- Teaching to individual learning styles has not been shown definitively to improve student learning. However, teaching in a variety of modes to appeal to all students in several ways has been shown to improve student learning.
- Testing encourages learning and can be used as a study tactic, not just a final assessment.
- Structuring long-range tasks into short-term chunks helps students learn continuously and avoid procrastination and last-minute cramming.

Research Fundamentals

Students take control: Strong memories depend on "top-down processing," in which learners select and elaborate on what they perceive, actively shaping their learning as it takes place. (This is related to Daniela Kaufer's point that learning is more effective when the student engages brain regions responsible for volition and executive function as well as for memory.) "Bottom-up processing" — passively allowing perceptions to occur and hoping to automatically construct a field of knowledge from them — is more commonly tried, but far less effective; it tends to result in weaker memories.

Make information meaningful: People remember information better when something is meaningful to them — for example, it is probably easier for you to remember your date of birth than it would be for you to remember a random string of six numbers. Teachers can take advantage of this phenomenon, known to psychologists as "elaborative encoding," by connecting course content to students' lives in any of a variety of ways.

Repetition and mnemonic study: Cognitive psychology research suggests that tried-and-true mnemonic techniques, such as the SQ3R Method and the PQ4R Method, take advantage of the way the mind and brain privilege memories that have been repeatedly encoded.

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Learning styles: Many people can identify a preferred way of taking in information (through hearing, seeing, reading, movement, etc.), and the preferences are sometimes called "learning styles." There is little research evidence supporting the idea that people have singular, fixed learning styles, and no clear evidence that students perform better on tests or assignments when instructional methods are tailored to their self-reported learning styles. In order to support robust learning, teachers should encourage all students to actively engage in the learning process in several ways and to develop a "style repertoire," or the ability to learn from content presented in a wide variety of forms.

Testing as learning tool: Recent research indicates that moderately stressful exercises in memory retrieval, such as quizzes and tests, enhance learning for the future (in addition to being valuable assessment tools). Testing may therefore be seen as another study tool rather than simply an end goal.

Procrastination and cramming: Cognitive research confirms that people often overestimate how far out the future is and concentrate on short-term, rather than long-term, tasks. In a word, we procrastinate. In order to minimize procrastination, instructors should set firm deadlines for clearly defined stages of projects and assignments. Students tend to **prefer** external constraints that help them to spread their work out over the course of the semester. Research shows that it is possible to teach people how to set their own deadlines, but that external requirements tend to be more effective.

Applications to Teaching

The SQ3R Method as described by University of Arizona Prof. Ron Wright.

The PQ4R Method from Prof. Kihlstrom's notes. It's a long document, so do a search (ctrl-f or cmd-f) within the page for **PQ4R**.

Tools for Learning from Purdue University Prof. Rod Allrich

Further Reading

Please note that some links may require Library proxy access. Please see the Library's page Connecting from Off Campus.

Graesser, Arthur, et al. "25 Learning Principles for Pedagogy and the Design of Learning Environments."

Ariely, D. and Wertenbroch, K."Procrastination, Deadlines, and Performance: Self-Control by Precommitment." *Psychological Science* 13.3 (May 2002): 219-224.

Pascarella, E. T., Seifert, T. A. and Whitt, E. J. "Effective Instruction and College Student Persistence: Some New Evidence." *New Directions for Teaching and Learning* 115 (Fall 2008): 55-70.

Pashler, H., et al. "Learning Styles: Concepts and Evidence." *Psychological Science in the Public Interest* 9 (Dec. 2008): 105-119.

Roediger, H. L. and Karpicke, J. D. "The Power of Testing Memory: Basic Research and Implications for Educational Practice." *Perspectives on Psychological Science* 1.3 (Sept. 2006): 181-210.

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Anthropology: Situated Learning in Communities of Practice

This article is based on talks by anthropologists Jean Lave, professor emerita from the Department of Geography, and Rosemary Joyce, professor in the Department of Anthropology, for the GSI Center's How Students Learn series in Spring 2011.

On this page:

Also available:
Video and summary of Jean Lave's talk
Video and summary of Rosemary Joyce's talk

Key Learning Principles

- Only learners can learn; teachers can't learn for them.
- Learning is a complex social phenomenon dependent on context; it is well described as "situated cognition."
- In their time in the academy, students are exposed to various disciplines that constitute "communities of practice." They begin learning how people participate in these communities.
- Apprenticeship learning takes place through "authentic" assignments and "legitimate" participation in the norms of the community of practice.

Research Fundamentals

Only learners can learn: Most often, when we start out to discuss how students learn we quickly shift to how we teach. It would be most useful to focus on the conditions and processes under which students learn, because teachers can't make students learn or do their learning for them. Students learn through practice (the things they do) as learners.

A complex social phenomenon dependent on context: "Situated cognition' is a theory of apprenticeship learning that emphasizes the social and contextual nature of the learning experience. Situated cognition theorists argue that the content of knowledge cannot be abstracted from the context in which both learning and practice take place.

Further discussion of social constructivist theory appears on the Social Constructivism page of the Teaching Guide.

Academic communities of practice: Situated cognition theory understands academic disciplines as communities of practice. That is, students learn how to participate in a disciplinary culture in the same way they become conditioned in the norms and practices of other types of communities, such as soccer teams and knitting circles. Even if students do not intend to pursue your discipline professionally, situated learning theory suggests that, in order to learn effectively, they need to perceive your discipline (whether structural engineering or art practice or history) as a culture and to participate in that culture as apprentices. If they do not treat the discipline as the culture in which they are participating, then "school" itself, as an artificial community of practice, may displace the discipline. This is what happens when

students "just want to know how to get an A"; they are participating in the culture of the schoolroom, but not in the culture of the discipline. However, if a student perceives that she is becoming part of the medical community, for example, then group work in her biochem class takes on social and practical importance for her own goals as a future professional.

Authentic and legitimate: In order to take advantage of situated cognition, learning activities and assignments should be authentic and legitimate. "Authenticity" in this context means that the activities and assignments should be part, if even a small part, of the normal academic and professional practices of the discipline. Schoolish assignments unrelated to any skills a professional in the field would engage in are, in this sense, inauthentic. "Legitimacy" has to do with the scope and scale of an assignment or activity: it should be scaled to students' immediate skills and capacities, as well as to the resources and time frame of the course.

An example of an illegitimate assignment is to have students construct a museum exhibit on an archaeological topic. It's illegitimate for a semester-length course because professional curators may take two years to research and assemble an exhibit. A legitimate variation of the assignment would be to research key objects that should appear in the exhibit and write a grant proposal to support construction of the exhibit.

Applications to Teaching

Communities of Practice from the nonprofit Informal Education Homepage (scroll to the bottom for "Conclusion — issues and implications for educators and animateurs").

Further Reading

Please note that some links may require Library proxy access. Please see the Library's page Connecting from Off Campus.

Lave, Jean and Etienne Wenger. *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge UP, 1991.

Brown, John Seely, Allan Collins, and Paul Duguid. "Situated Cognition and the Culture of Learning." *Educational Researcher* 18.1 (Jan.–Feb. 1989): 32–42.

Darvin, Jacqueline. "'Real-World Cognition Doesn't End When the Bell Rings': Literacy Instruction Strategies Derived From Situated Cognition Research." *Journal of Adolescent & Adult Literacy* 49.5 (Feb. 2006): 398–407.

Choi, Jeong-Im and Michael Hannafin. "Situated Cognition and Learning Environments: Roles, Structures, and Implications for Design." *Educational Technology Research and Development* 43.2 (1995): 53–69.

Rosemary Joyce's Berkeley Blog posts on teaching and learning: Read more about how Prof. Joyce interprets these learning principles in her own classroom. "Learning is breaking out all around." Feb. 9, 2010. "Great teaching can happen in many different ways…" April 21, 2010.

Teaching Guide for GSIs

Psychology: Motivation and Learning

This article is based on a talk by Martin Covington, professor of the Graduate School in Psychology, for the GSI Center's How Students Learn series in Spring 2011.

On this page:

Also available:
Video and full summary of Martin Covington's talk "Why Students Learn and (Sometimes) Don't Learn

Key Learning Principles

- Student motivation is sometimes driven by fear of failure, based on the belief that grades amount to a judgment of their personal ability or intelligence rather than their performance on a specific learning task. This is part of what drives intense student interest in achieving high grades, in addition to beliefs about how their grades may influence future prospects.
- To instructors, grades don't hold the same meaning as for students; instructors' primary goal is for students to learn the course material for its own sake. Because students are so invested in grades, their expectations of a course can be very different from or at odds with their teachers' expectations.
- Learning environments and course designs that leverage intrinsic motivation — student curiosity and interest — improve the quality of students' learning.

Research Fundamentals

Extrinsic motivation and fear of failure: When asked what makes them study and work hard in college, undergraduates typically say that they are trying to get the best grade possible. Grades, in fact, are the primary focus of most students (an extrinsic motivation). Only as secondary reasons do students list the desires to become competent, to prove themselves, and to avoid mistakes (intrinsic motivations). Learning about the content of the course for its own sake is the last of the reasons students give.

Conflicting expectations: As a result, students' goals tend to be mismatched with their instructors' objectives. First-year students, and many students beyond the freshmen level, tend to believe that it is their responsibility simply to follow directions and to absorb course content. They think that instructors should simply present and explain material, and that instructors are responsible for making that material interesting, relevant, and fun. Although there may be some truth to these perceptions, most instructors want to do far more — to encourage active engagement with the material, to foster students' ability to self-monitor their learning, and to create a safe environment in which students can be inquisitive learners.

Leveraging intrinsic motivation: Several strategies can connect with students' interests so that they come closer to their instructors' goals for them.

- Organize a lesson plan around a problem for students to solve using the course material. The problem should relate to things students are already interested in — for example, in a pre-med microbiology course, having students put themselves in the place of a pediatrician figuring out which systems are at issue given a hypothetical patient's symptoms.

Teaching Guide for GSIs

- If you are creating your own course, organize the entire course around a large question or problem that the course material will eventually enable them to accurately explain and solve.
- Connect course material with the non-academic world.
- Take advantage of events the students are interested in to explore how your field views the issues involved.
- Curiosity is great for priming intrinsic interest. Bring in anomalies or curiosities that students can use the course material to analyze and explain.

Applications to Teaching

Motivating Students from Vanderbilt University's Center for Teaching

Further Reading

Please note that some links may require Library proxy access. Please see the Library's page Connecting from Off Campus.

Kyndt, Eva et al. "The Direct and Indirect Effect of Motivation for Learning on Students' Approaches to Learning through the Perceptions of Workload and Task Complexity." *Higher Education Research and Development* 30.2 (April 2011): 135–150.

Teaching Guide for GSIs

Education: Organizing the Learning Process

This article is based on a talk by Lawrence Lowery, Professor Emeritus in the Graduate School of Education, for the GSI Center's How Students Learn series in Spring 2011.

On this page:

Also available:
Video and summary of Lawrence Lowery's talk "Effective Teaching for Effective Learning"

Key Learning Principles

- Content knowledge alone is not enough to make an instructor effective; an understanding of how learning works is also essential.
- Effective teachers use curiosity to motivate students and promote memory.
- Effective teachers use different methods for teaching skills from those they use to teach knowledge.
- Effective teachers tap into students' prior knowledge and help them shift away from their misconceptions.

Research Fundamentals

Content knowledge is not enough: Research indicates that highly intelligent and educated people tend to have an "expert blind spot" which hampers them in recognizing how difficult it is for a novice to understand the fundamental principles of their area of expertise. GSIs, who are still at a level of "conscious competence," may be able to sympathize with undergraduates' learning challenges in the discipline more readily; faculty, who are at a level of "unconscious competence" may need to work harder to remember the conceptual challenges undergraduates face.

Mobilize student curiosity: Research shows curiosity and fright are the two primary mechanisms by which the brain is prompted to learn and remember information. Frightening our students would not be ethical, of course; it would also tend to restrict brain activity to the stress response. However, we can, and must, capitalize on the power of curiosity to promote robust learning.

Teaching skills versus teaching knowledge: In order to teach skills, instructors need to tutor and coach their students, give immediate corrections and refinements, and encourage students to practice the skills repeatedly until they are automatic. Teaching knowledge, however, is different. The best way for students to learn knowledge is for them to do "rehearsal teaching," that is trying to explain the concepts themselves. Stabilizing knowledge in the long-term memory happens by repeating the content with some differences each time. Thus, effective teachers are flexible and present content in many different ways. If we only present content once, or we are only capable of presenting it in one way, then our students tend to simply memorize the information, rather than developing a detailed critical understanding of it. Memorizing often leads to misconceptions, so we should aim for our content to be "memorable" rather than "memorizable."

Teaching Guide for GSIs

Tap into prior knowledge: Students usually have both prior knowledge and misconceptions that influence their ability to learn new information in any given context, including a college course. Research shows that it can be extremely difficult to address student misconceptions of basic scientific principles, writing objectives, or philosophical ideas. Instructors should devote time and resources to ascertaining the state of students' prior knowledge, connecting new knowledge to old, and helping students identify and correct misconceptions.

Applications to Teaching

Strategies for Instruction by Lawrence Lowery, from the Lawrence Hall of Science Full Option Science System (FOSS) Newsletter, #11 (Spring 1998)

Assessing Prior Knowledge from Carnegie Mellon's Eberly Center for Teaching Excellence

Further Reading

Please note that some links may require Library proxy access. Please see the Library's page Connecting from Off Campus.

Ambrose, Susan, et al. (2010). *How Learning Works: Seven Research-Based Principles for Smart Teaching*. San Francisco: Jossey-Bass. See Chapter 1, "How does Students' Prior Knowledge Affect their Learning?" and Chapter 5, "How do Students Develop Mastery?"

Leach, Linda and Nick Zepke. "Engaging Students in Learning: A Review of a Conceptual Organiser." *Higher Education Research and Development* 30.2 (April 2011): 193–204.

McCune, Velda and Noel Entwistle. "Cultivating the Disposition to Understand in 21st Century University Education." *Learning and Individual Differences* 21.3 (June 2011): 303–310.

Medina, John. *Brain Rules: 12 Principles for Surviving and Thriving at Work, Home and School* (Pear Press, 2008).

National Research Council, U.S. *How People Learn: Brain, Mind, Experience, and School*, 2000.

Teaching Guide for GSIs

Education: Learning to Think in a Discipline

This article is based on a talk by Alan Schoenfeld, professor in the School of Education, for the GSI Center's How Students Learn series in Spring 2011.

On this page:

Also available:
Video and summary of Alan Schoenfeld's talk

Key Learning Principles

- Students learn content, but they learn most effectively when they also learn disciplinary and professional frameworks for analysis and application of content knowledge.
- Students need to learn problem-solving strategies for situations that have no obvious solutions or explicit procedures laid out.
- Metacognition, the ability to analyze one's own critical thinking process and to adjust it when necessary, is an essential element of robust learning.

Research Fundamentals

Disciplinary and professional frameworks: Students, particularly undergraduate students, are not simply amassing facts; they are acquiring "disciplinary habits of mind" that provide them with the analytical framework and context in which to use their knowledge. Although we typically realize that the content of our knowledge makes a difference to our ability to solve problems, we don't always consider how we know it, or recognize our interpretive filters. When working with students, we need to be able to evaluate the interpretive filters they have developed. That is, being a good teacher means more than being able to explain the same thing in multiple ways — good teachers need to recognize how students know the material, and be able to intervene when their understandings falter.

Problem-solving strategies: Most disciplines students find in college involve some kind of problem solving activity — attempts to confront situations that do not have obvious answers or obvious procedures to find answers. As researchers in our disciplines, we can usually identify problems fruitfuly and can apply appropriate strategies to define and resolve a problem. Our students often do not yet have this kind of knowledge, so they need to learn relevant problem-solving strategies.

Also called "heuristics," problem-solving strategies can be identified in every discipline. For example in writing and composition, in which students must improve a paper from one draft to the next, the heuristics may include guidance to outline the first draft, identify topic sentences in all the paragraphs, and question the basic argument and rhetorical structures. In mathematics, heuristics include approaches like drawing a diagram of a problem, looking at individual cases, solving an easier related problem, and establishing sub-goals. Students can be taught these strategies.

Metacognition: In order to solve problems effectively, we must control, monitor, and self-regulate our thinking. This awareness of how we know and apply our knowledge is known as metacognition. What we

know matters, but awareness of how and when we use our knowledge matters even more. In mathematics, a student may pick a formula to work through a problem and pour copious amounts of energy into calculation, not realizing after coming up with an implausible answer that the formula he chose doesn't fit the nature of the problem. A student tasked with writing a book review may not stop to consider the difference between a book review (an academic genre) and a book report (a schoolish genre) and write the wrong kind of paper. Or students may have only limited strategies for preparing to take a midterm exam, receive a disappointing grade, and not understand why their preparation strategy was not adequate.

Keeping a writing or study log, writing a brief few sentences about how they think their paper turned out, and learning to use heuristics are some of the ways in which students can learn metacognition and become more self-regulated in their intellectual work.

Applications to Teaching

Teaching Metacognition from Carleton College's Geoscience Department (applicable to all disciplines)

Exam Wrappers from Carnegie Mellon's Eberly Center for Teaching and Learning

Teaching Problem Solving from Vanderbilt University's Center for Teaching

Further Reading

Please note that some links may require Library proxy access. Please see the Library's page Connecting from Off Campus.

Brown, John Seely, Allan Collins, and Paul Duguid. "Situated Cognition and the Culture of Learning." *Educational Researcher* 18.1 (Jan.-Feb. 1989): 32–42.

Clauss, Jon and Kevin Geedey. "Knowledge Surveys: Students' Ability to Self-Assess." *Journal of the Scholarship of Teaching and Learning* 10.2 (June 2010): 14–24.

Halpern, Diane F. "Teaching for Critical Thinking: Helping College Students Develop the Skills and Dispositions of a Critical Thinker." *New Directions for Teaching and Learning* 80 (Winter 1999): 69–74.