Instructional Design
&
Learning Theory

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Introduction:

To students of instructional design the introduction and subsequent "sorting out" of the various learning theories and associated instructional design strategies can be somewhat confusing. It was out of this feeling of cognitive dissonance that this site was born.

Why does it seem so difficult to differentiate between three basic theories of learning? Why do the names of theorists appear connected to more than one theory? Why do the terms and strategies of each theory overlap?

The need for answers to these questions sparked my investigation into the available literature on learning theories and their implications for instructional design. I found many articles and internet sites that dealt with learning theory and ID, in fact, it was difficult to know when and where to draw the line. When I stopped finding new information, and the articles were reaffirming what I had already read, I began to write.

The writing process was a learning experience for me and now that I have finished, I want to start over and make it even better, because I know more now than I did when I began. Every time I reread an article, there were ideas and lists that I would wish to add to my writing. Perhaps in further development of this site I will change and refine my presentation.

Reading about the development of learning theories and their connection to instructional design evoked, for me, many parallels with the development of other theories in sciences. I have included some of those thoughts as asides within the main body of text.

Besides behaviorism, cognitivism and constructivism one could discuss such topics as connoisseurship, semiotics, and contextualism, but I decided that a clear understanding of the basic learning theories would be best. The main sections of this site are as follows:

What are Theories and Models?

- What is a theory?
    - A theory provides a general explanation for observations made over time.
    - A theory explains and predicts behavior.
    - A theory can never be established beyond all doubt.
    - A theory may be modified.
    - Theories seldom have to be thrown out completely if thoroughly tested but sometimes a theory may be widely accepted for a long time and later disproved.

  (Dorin, Demmin & Gabel, 1990)

- What is a model?
    - A model is a mental picture that helps us understand something we cannot see or experience directly.

  (Dorin, Demmin & Gabel, 1990)

Behaviorism, Cognitivism and Constructivism - The Basics

Behaviorism: Based on observable changes in behavior. Behaviorism focuses on a new behavioral pattern being repeated until it becomes automatic.

Cognitivism: Based on the thought process behind the behavior. Changes in behavior are observed, and used as indicators as to what is happening inside the learner's mind.

Constructivism: Based on the premise that we all construct our own perspective of the world, through individual experiences and schema. Constructivism focuses on preparing the learner to problem solve in ambiguous situations.

(Schuman, 1996)

The Basics of Behaviorism

Behaviorism, as a learning theory, can be traced back to Aristotle, whose essay "Memory" focused on associations being made between events such as lightning and thunder. Other philosophers that followed Aristotle's thoughts are Hobbs (1650), Hume (1740), Brown (1820), Bain (1855) and Ebbinghause (1885) (Black, 1995).

The theory of behaviorism concentrates on the study of overt behaviors that can be observed and measured (Good & Brophy, 1990). It views the mind as a "black box" in the sense that response to stimulus can be observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind. Some key players in the development of the behaviorist theory were Pavlov, Watson, Thorndike and Skinner.

Pavlov (1849 - 1936)

For most people, the name "Pavlov" rings a bell (pun intended). The Russian physiologist is best known for his work in classical conditioning or stimulus substitution. Pavlov's most famous experiment involved food, a dog and a bell.

Pavlov's Experiment

- Before conditioning, ringing the bell caused no response from the dog. Placing food in front of the dog initiated salivation.
- During conditioning, the bell was rung a few seconds before the dog was presented with food.
- After conditioning, the ringing of the bell alone produced salivation

  (Dembo, 1994).

Stimulus and Response Items of Pavlov's Experiment

Food	Unconditioned Stimulus
Salivation	Unconditioned Response (natural, not learned)
Bell	Conditioned Stimulus
Salivation	Conditioned Response (to bell)

Other Observations Made by Pavlov

- Stimulus Generalization: Once the dog has learned to salivate at the sound of the bell, it will salivate at other similar sounds.
- Extinction: If you stop pairing the bell with the food, salivation will eventually cease in response to the bell.
- Spontaneous Recovery: Extinguished responses can be "recovered" after an elapsed time, but will soon extinguish again if the dog is not presented with food.
- Discrimination: The dog could learn to discriminate between similar bells (stimuli) and discern which bell would result in the presentation of food and which would not.
- Higher-Order Conditioning: Once the dog has been conditioned to associate the bell with food, another unconditioned stimulus, such as a light may be flashed at the same time that the bell is rung. Eventually the dog will salivate at the flash of the light without the sound of the bell.

(What was the name of that dog??)

Thorndike (1874 - 1949)

Edward Thorndike did research in animal behavior before becoming interested in human psychology. He set out to apply "the methods of exact science" to educational problems by emphasizing "accurate quantitative treatment of information". "Anything that exists, exists in a certain quantity and can be measured" (Johcich, as cited in Rizo, 1991). His theory, Connectionism, stated that learning was the formation of a connection between stimulus and response.

- The "law of effect" stated that when a connection between a stimulus and response is positively rewarded it will be strengthened and when it is negatively rewarded it will be weakened. Thorndike later revised this "law" when he found that negative reward, (punishment) did not necessarily weaken bonds, and that some seemingly pleasurable consequences do not necessarily motivate performance.

- The "law of exercise" held that the more an S-R (stimulus response) bond is practiced the stronger it will become. As with the law of effect, the law of exercise also had to be updated when Thorndike found that practice without feedback does not necessarily enhance performance.
- The "law of readiness" : because of the structure of the nervous system, certain conduction units, in a given situation, are more predisposed to conduct than others.

Thorndike's laws were based on the stimulus-response hypothesis. He believed that a neural bond would be established between the stimulus and response when the response was positive. Learning takes place when the bonds are formed into patterns of behavior (Saettler, 1990).

Watson (1878 - 1958)

John B. Watson was the first American psychologist to use Pavlov's ideas. Like Thorndike, he was originally involved in animal research, but later became involved in the study of human behavior.

Watson believed that humans are born with a few reflexes and the emotional reactions of love and rage. All other behavior is established through stimulus-response associations through conditioning.

Watson's Experiment

Watson demonstrated classical conditioning in an experiment involving a young child (Albert) and a white rat. Originally, Albert was unafraid of the rat; but Watson created a sudden loud noise whenever Albert touched the rat. Because Albert was frightened by the loud noise, he soon became conditioned to fear and avoid the rat. The fear was generalized to other small animals. Watson then "extinguished" the fear by presenting the rat without the loud noise. Some accounts of the study suggest that the conditioned fear was more powerful and permanent than it really was. (Harris, 1979; Samelson, 1980, in Brophy, 1990)

Certainly Watson's research methods would be questioned today; however, his work did demonstrate the role of conditioning in the development of emotional responses to certain stimuli. This may explain certain fears, phobias and prejudices that people develop.

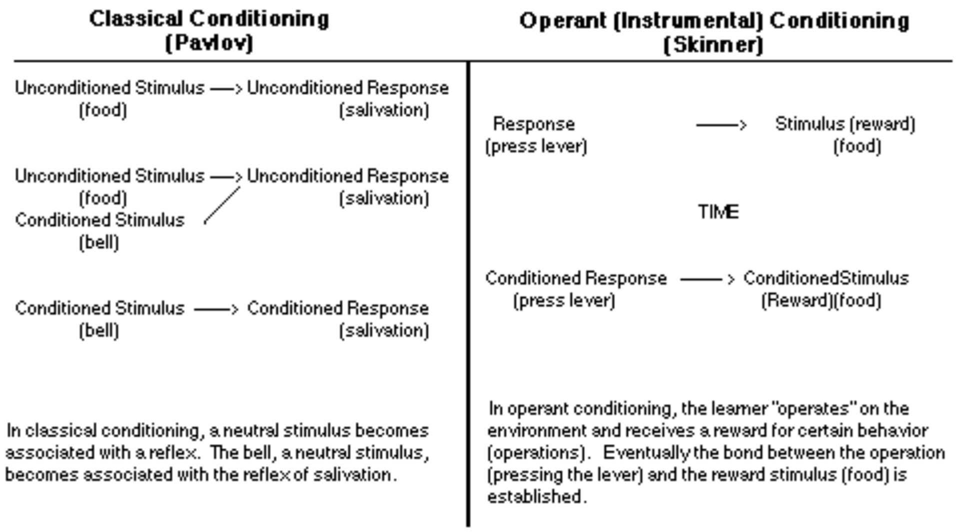
(Watson is credited with coining the term "behaviorism")

Skinner (1904 - 1990)

Like Pavlov, Watson and Thorndike, Skinner believed in the stimulus-response pattern of conditioned behavior. His theory dealt with changes in observable behavior, ignoring the possibility of any processes occurring in the mind. Skinner's 1948 book, *Walden Two* , is about a utopian society based on operant conditioning. He also wrote *Science and Human Behavior,* (1953) in which he pointed out how the principles of operant conditioning function in social institutions such as government, law, religion, economics and education (Dembo, 1994).

Skinner's work differs from that of his predecessors (classical conditioning), in that he studied operant behavior (voluntary behaviors used in operating on the environment).

Difference between Classical and Operant Conditioning



Skinner's Operant Conditioning Mechanisms

- Positive Reinforcement or reward: Responses that are rewarded are likely to be repeated. (Good grades reinforce careful study.)
- Negative Reinforcement: Responses that allow escape from painful or undesirable situations are likely to be repeated. (Being excused from writing a final because of good term work.)
- Extinction or Non-Reinforcement : Responses that are not reinforced are not likely to be repeated. (Ignoring student misbehavior should extinguish that behavior.)
- Punishment: Responses that bring painful or undesirable consequences will be suppressed, but may reappear if reinforcement contingencies change. (Penalizing late students by withdrawing privileges should stop their lateness.)

(Good & Brophy, 1990)

Skinner and Behavioral Shaping

If placed in a cage an animal may take a very long time to figure out that pressing a lever will produce food. To accomplish such behavior successive approximations of the behavior are rewarded until the animal learns the association between the lever and the food reward. To begin shaping, the animal may be rewarded for simply turning in the direction of the lever, then for moving toward the lever, for brushing against the lever, and finally for pawing the lever.

Behavioral chaining occurs when a succession of steps need to be learned. The animal would master each step in sequence until the entire sequence is learned.

Reinforcement Schedules

Once the desired behavioral response is accomplished, reinforcement does not have to be 100%; in fact it can be maintained more successfully through what Skinner referred to as partial reinforcement schedules. Partial reinforcement schedules include interval schedules and ratio schedules.

- Fixed Interval Schedules: the target response is reinforced after a fixed amount of time has passed since the last reinforcement.
- Variable Interval Schedules: similar to fixed interval schedules, but the amount of time that must pass between reinforcement varies.
- Fixed Ratio Schedules: a fixed number of correct responses must occur before reinforcement may recur.
- Variable Ratio Schedules: the number of correct repetitions of the correct response for reinforcement varies.

Variable interval and especially, variable ratio schedules produce steadier and more persistent rates of response because the learners cannot predict when the reinforcement will come although they know that they will eventually succeed. *< Not necessarily effective in the classroom - a lack of predictability threatens classroom management & may decrease the perceived safety of the learning environment*

(Have you checked your Lottery tickets lately?)

The Basics of Cognitivism

As early as the 1920's people began to find limitations in the behaviorist approach to understanding learning. Edward Tolman found that rats used in an experiment appeared to have a mental map of the maze he was using. When he closed off a certain portion of the maze, the rats did not bother to try a certain path because they "knew" that it led to the blocked path. Visually, the rats could not see that the path would result in failure, yet they chose to take a longer route that they knew would be successful (Operant Conditioning [On-line]).

Behaviorists were unable to explain certain social behaviors. For example, children do not imitate all behavior that has been reinforced. Furthermore, they may model new behavior days or weeks after their first initial observation without having been reinforced for the behavior. Because of these observations, Bandura and Walters departed from the traditional operant conditioning explanation that the child must perform and receive reinforcement before being able to learn. They stated in their 1963 book,*Social Learning and Personality Development*, that an individual could model behavior by observing the behavior of another person. This theory lead to Bandura's Social Cognitive Theory (Dembo, 1994).

What is Cognitivism?

> "Cognitive theorists recognize that much learning involves associations established through contiguity and repetition. They also acknowledge the importance of reinforcement, although they stress its role in providing feedback about the correctness of responses over its role as a motivator. However, even while accepting such behavioristic concepts, cognitive theorists view learning as involving the acquisition or reorganization of the cognitive structures through which humans process and store information." (Good and Brophy, 1990, pp. 187).

As with behaviorism, cognitive psychology can be traced back to the ancient Greeks, Plato and Aristotle. The cognitive revolution became evident in American psychology during the 1950's (Saettler, 1990). One of the major players in the development of cognitivism is Jean Piaget, who developed the major aspects of his theory as early as the 1920's. Piaget's ideas did not impact North America until the 1960's after Miller and Bruner founded the Harvard Center for Cognitive studies.

Key Concepts of Cognitive Theory

- Schema - An internal knowledge structure. New information is compared to existing cognitive structures called "schema". Schema may be combined, extended or altered to accommodate new information.
- Three-Stage Information Processing Model - input first enters a sensory register, then is processed in short-term memory, and then is transferred to long-term memory for storage and retrieval.
    - Sensory Register - receives input from senses which lasts from less than a second to four seconds and then disappears through decay or replacement. Much of the information never reaches short term memory but all information is monitored at some level and acted upon if necessary.
    - Short-Term Memory (STM) - sensory input that is important or interesting is transferred from the sensory register to the STM. Memory can be retained here for up to 20 seconds or more if rehearsed repeatedly. Short-term memory can hold up to 7 plus or minus 2 items. STM capacity can be increased if material is chunked into meaningful parts.
    - Long-Term Memory and Storage (LTM) - stores information from STM for long term use. Long-term memory has unlimited capacity. Some materials are "forced" into LTM by rote memorization and over learning. Deeper levels of processing such as generating linkages between old and new information are much better for successful retention of material.
- Meaningful Effects - Meaningful information is easier to learn and remember. (Cofer, 1971, in Good and Brophy, 1990) If a learner links relatively meaningless information with prior schema it will be easier to retain. (Wittrock, Marks, & Doctorow, 1975, in Good and Brophy, 1990)

- Serial Position Effects - It is easier to remember items from the beginning or end of a list rather than those in the middle of the list, unless that item is distinctly different.
- Practice Effects - Practicing or rehearsing improves retention especially when it is distributed practice. By distributing practices the learner associates the material with many different contexts rather than the one context afforded by mass practice.
- Transfer Effects- The effects of prior learning on learning new tasks or material.
- Interference Effects - Occurs when prior learning interferes with the learning of new material.
- Organization Effects - When a learner categorizes input such as a grocery list, it is easier to remember.
- Levels of Processing Effects - Words may be processed at a low-level sensory analysis of their physical characteristics to high-level semantic analysis of their meaning. (Craik and Lockhart, 1972, in Good and Brophy, 1990) The more deeply a word is process the easier it will be to remember.
- State Dependent Effects - If learning takes place within a certain context it will be easier to remember within that context rather than in a new context.
- Mnemonic Effects - Mnemonics are strategies used by learners to organize relatively meaningless input into more meaningful images or semantic contexts. For example, the notes of a musical scale can be remembered by the rhyme: Every Good Boy Deserves Fruit.
- Schema Effects - If information does not fit a person's schema it may be more difficult for them to remember and what they remember or how they conceive of it may also be affected by their prior schema.
- Advance Organizers - Ausebels advance organizers prepare the learner for the material they are about to learn. They are not simply outlines of the material, but are material that will enable the student to make sense out of the lesson.

The Basics of Constructivism

Bartlett (1932) pioneered what became the constructivist approach (Good & Brophy, 1990). Constructivists believe that "learners construct their own reality or at least interpret it based upon their perceptions of experiences, so an individual's knowledge is a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events." "What someone knows is grounded in perception of the physical and social experiences which are comprehended by the mind." (Jonasson, 1991).

If each person has their own view about reality, then how can we as a society communicate and/or coexist? Jonassen, addressing this issue in his article *Thinking Technology: Toward a Constructivist Design Model,* makes the following comments:

- "Perhaps the most common misconception of constructivism is the inference that we each therefore construct a unique reality, that reality is only in the mind of the knower, which will doubtlessly lead to intellectual anarchy."
- "A reasonable response to that criticism is the Gibsonian perspective that contends that there exists a physical world that is subject to physical laws that we all know in pretty much the same way because those physical laws are perceivable by humans in pretty much the same way."
- "Constructivists also believe that much of reality is shared through a process of social negotiation..."

If one searches through the many philosophical and psychological theories of the past, the threads of constructivism may be found in the writing of such people as Bruner, Ulrick, Neiser, Goodman, Kant, Kuhn, Dewey and Habermas. The most profound influence was Jean Piaget's work which was interpreted and extended by von Glasserfield (Smorgansbord, 1997).

Realistic vs. Radical Construction

Realistic constructivism - cognition is the process by which learners eventually construct mental structures that correspond to or match external structures located in the environment.

Radical constructivism - cognition serves to organize the learners experiential world rather than to discover ontological reality

(Cobb, 1996, in Smorgansbord, 1997).

The Assumptions of Constructivism - Merrill

- knowledge is constructed from experience
- learning is a personal interpretation of the world
- learning is an active process in which meaning is developed on the basis of experience
- conceptual growth comes from the negotiation of meaning, the sharing of multiple perspectives and the changing of our internal representations through collaborative learning
- learning should be situated in realistic settings; testing should be integrated with the task and not a separate activity

  (Merrill, 1991, in Smorgansbord, 1997)

It Boggles the Mind!

If you are reading about learning theories, you may notice that it is difficult to pin down what theory a certain theorist belongs to. This can confuse you, since, just as you think you have it cased, a name you originally thought was in the behavioral category shows up in a constructivism article.

This problem is often the result of theorists and their ideas evolving over time and changes they make to their original ideas. Davidson includes the following example in an article she wrote:

"Considered by most to be representative of [a] behaviourist learning paradigm, Gagne's theory of learning and events of instruction have evolved progressively to approach a more cognitive theory. His discussion of relating present information and past knowledge (event #3) and the inclusion of learning transfer (event#9) are indicative of this shift toward constructivism." (Davidson, 1998)

Okay? Okay. :-)

Comparing The Development of Learning Theories to the Development of the Atomic Theory

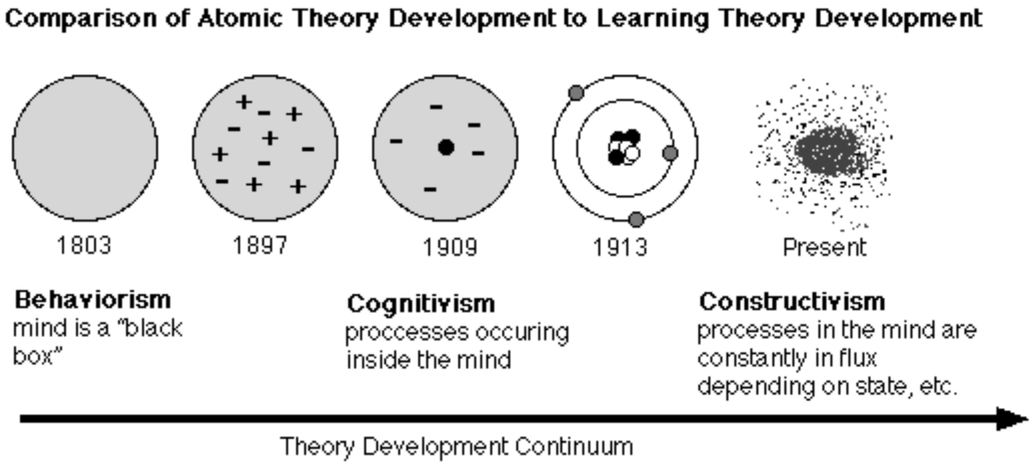
Atomic Theory

Since the beginning of history, people have theorized about the nature of matter. The ancient Greeks thought that matter was composed of fire, water, earth and air. Another view, the continuous theory, was that matter could be infinitely subdivided into smaller and smaller pieces without change. The Greek philosophers, Democritis and Lucippus, came up with the idea that matter made up of particles so small that they cannot be divided into anything smaller. They called their particles "atomos", which is the Greek word for "indivisible". It wasn't until the 18th century that anyone could prove one theory was better than another. John Dalton in 1803, with his law of multiple proportions, proposed a theory of matter based on the existence of atoms. The rest is history:

- 1803 Dalton's Atomic Theory.
- 1870 Crookes finds the first evidence of electrons.
- 1890's J.J. Thompson realized cathode rays are negative particles (electrons).
- 1909 Rutherford discovered alpha particles and said that atoms consist of small positively charged particles surrounded by mostly empty space where electrons moved around.

- 1913 Niels Bohr develops a new model of the atom with electron energy levels or orbits.
- 1930's and 1940's The atom had a positive nucleus with an electron charge cloud. This theory was referred to as the orbital model and the quantum-mechanical model.

  (Dorin, Demmin & Gabel, 1990)



Learning Theory

Given that we will most likely never "see" an atom, we will never "see" learning either. Therefore our learning models are mental pictures that enable us to understand that which we will never see. Does the development of learning theory follow a similar pattern as the atomic theory?

It seems that learning theories, like the study of matter can be traced back to the ancient Greeks. In the 18th century, with the onset of scientific inquiry, people began in ernest to study and develop models of learning. The behaviorist learning theory centered around that which was observable, not considering that there was anything occurring inside the mind. Behaviorism can be compared to Dalton's atom, which was simply a particle. Using overt behavior as a starting point, people began to realize that there is something happening inside the organism that should be considered, since it seemed to affect the overt behavior. Similarly, in physical science, people such as Crookes, Thompson, Rutherford and Bohr realized that there was something occurring within the atom causing its behavior. Thus the cognitive model of learning was born. Soon, however, theorists realized that the "atom" is not stable, it is not so "cut and dried". Enter the constructivist learning theory which tells us that each organism is constantly in flux, and although the old models work to a certain degree, other factors most also be considered. Could the constructivist approach be considered to be the quantum theory of learning?

The quantum theory builds upon the previous atomic theories. Constructivism builds upon behaviorism and cognitivism in the sense that it accepts multiple perspectives and maintains that learning is a personal interpretation of the world. I believe that behavioral strategies can be part of a constructivist learning situation, if that learner choses and finds that type of learning suitable to their experiences and learning style. Cognitive approaches have a place in constructivism also, since constructivism recognises the concept of schema and building upon prior knowledge and experience. Perhaps the greatest difference is that of evaluation. In behaviorism and cognitivism, evaluation is based on meeting specific objectives, whereas in constructivism, evaluation is much more subjective. Of course, what if I, as a learner, negotiate my evaluation and wish to include objective evaluation? Then isn't behavioral and cognitive strategy a part of constructivism?

Perhaps the learning theory used depends upon the learning situation, just as the atomic theory used, depends upon the learning situation. The bohr atom is often used to introduce the concept of protons, neutrons and electrons to grade school students. Perhaps behaviorism is suitable to certain basic learning situations, whereas "quantum" constructivism is better suited to advanced learning situations.

A Biological Analogy to Learning Theory Classification

The classification of learning theories is somewhat analogous to the classification system designed by biologists to sort out living organisms. Like any attempt to define categories, to establish criteria, the world does not fit the scheme in all cases. Originally there was a plant kingdom and an animal kingdom, but eventually organisms that contained cholophyll and were mobile needed to be classified. The protist kingdom was established. The exact criteria for protists are still not established, but it is a classification that gives us a place for all of the organisms that don't fit neatly into either the plant or animal kingdoms.

To extend the analogy, biologists continued to modify the classification system as know knowledge and insights into existing knowledge were discovered. The advent of new technology such as the electron microscope enabled the addition of the monera kingdom. Recently, the distinctive features of fungi have brought about a proposal for a fifth kingdom, fungi. This development and adjustment of the taxonomy remins one of behaviourism, cognitivism, constructivism, postmodernism, contextualism, semiotics...

Distinguishing One Learning Theory from Another

In an article writen by Peggy Ertmer and Timothy Newby they use Schunk's (1991 in Ertmer & Newby, 1993) five definitive questions plus two more of their own to distinguish each learning theory from the others.

1. How does learning occur!
2. Which factors influence learning?
3. What is the role of memory?
4. How does transfer occur?
5. What types of learning are best explained by the theory?

...and for the instructional designer..

6. What basic assumptions/principles of this theory are relevant to instructional design?
7. How should instruction be structured to facilitate learning?

The History of Behaviorism, Cognitivism and Constructivism in Instructional Design

Behaviorism and Instructional Design

** This section on behaviorism is largely a synopsis of information from Paul Saettler's book, *The History of American Educational Technology*, (1990).

In Paul Saettler's book *The History of American Educational Technology*, he states that behaviorism did not have an impact on educational technology until the 1960s, which was the time that behaviorism actually began to decrease in popularity in American psychology. Saettler identified six areas that demonstrate the impact of behaviorism on Educational Technology in America: the behavioral objectives movement; the teaching machine phase; the programmed instruction movement; individualized instructional approaches, computer-assisted learning and the systems approach to instruction.

Behavioral Objectives Movement:

A behavioral objective states learning objectives in "specified, quantifiable, terminal behaviors" (Saettler, pp. 288, 1990). Behavioral objectives can be summed up using the mnemonic device ABCD (Schwier, 1998).

Example: After having completed the unit the student will be able to answer correctly 90% of the questions on the posttest.

- A - Audience - the student
- B - Behavior - answer correctly
- C - Condition - after having completed the unit, on a post test
- D - Degree - 90% correct

To develop behavioral objectives a learning task must be broken down through analysis into specific measurable tasks. The learning success may be measured by tests developed to measure each objective.

The advent of behavioral objectives can be traced back to the Elder Sophists of ancient Greece, Cicero, Herbart and Spencer, but Franklin Bobbitt developed the modern concept of behavioral objectives in the early 1900s (Saettler, 1990).

Taxonomic Analysis of Learning Behaviors

- **Bloom's Taxonomy of Learning** - In 1956 Bloom and his colleagues began development of a taxonomy in the cognitive, attitudinal (affective) and psychomotor domains. Many people are familiar with **Bloom's Cognitive taxonomy**:
  - knowledge
  - comprehension
  - application
  - analysis
  - synthesis
  - evaluation

- **Gagne's Taxonomy of Learning** - Robert Gagne developed his taxonomy of learning in 1972. Gagne's taxonomy was comprised of five categories:
  - verbal information
  - intellectual skill
  - cognitive strategy
  - attitude
  - motor skill

Mastery Learning

Mastery learning was originally developed by Morrison in the 1930s. His formula for mastery was "Pretest, teach, test the result, adapt procedure, teach and test again to the point of actual learning." (Morrison, 1931, in Saettler, 1990). Mastery learning assumes that all students can master the materials presented in the lesson. Bloom further developed Morrison's plan, but mastery learning is more effective for the lower levels of learning on Bloom's taxonomy, and not appropriate for higher level learning (Saettler, 1990).

Military and Industrial Approach

For military and industrial training, "behavioral objectives were written descriptions of specific, terminal behaviors that were manifested in terms of observable, measurable behavior." (Saettler, 1990) Robert Mager wrote *Preparing Instructional Objectives,* in 1962 which prompted interest and use of behavioral objectives among educators. Gagne and Briggs who also had backgrounds in military and industrial psychology developed a set of instructions for writing objectives that is based on Mager's work.

- **Gagne's and Brigg's Model**
    - Action
    - Object
    - Situation
    - Tools and Constraints
    - Capability to be Learned

By the late 1960's most teachers were writing and using behavioral objectives. There were, of course, people who questioned the breaking down of subject material into small parts, believing that it would lead away from an understanding of the "whole" (Saettler, 1990).

Accountability Movement

A movement known as scientific management of industry arose in the early 1900s in response to political and economic factors of that time. Franklin Bobbitt proposed utilization of this system in education stressing that the standards and direction of education should stem from the consumer - society. Bobbitt's ideas exemplified the idea of accountability, competency-based education and performance-based education, which because of similar economic and political factors, experienced a revival in America during the late 1960s and 1970s (Saettler, 1990).

Teaching Machines and Programmed Instruction Movement

Although the elder Sophists, Comenius, Herbart and Montessori used the concept of programmed instruction in their repertoire, B.F. Skinner is the most current and probably best known advocate of teaching machines and programmed learning. Contributors to this movement include the following:

- Pressey - introduced a multiple-choice machine at the 1925 American Psychological Association meeting.
- Peterson - a former student of Pressey's who developed "chemosheets" in which the learner checked their answers with a chemical-dipped swab.
- W.W.II - devises called "phase checks", constructed in the 1940s and 1950s, taught and tested such skills and dissassembly-assembly of equipment.
- Crowder - designed a branched style of programming for the US Air force in the 1950s to train troubleshooters to find malfunctions in electronic equipment.
- Skinner - based on operant conditioning Skinner's teaching machine required the learner to complete or answer a question and then receive feedback on the correctness of the response. Skinner demonstrated his machine in 1954.

  (Saettler, 1990)

Early Use of Programmed Instruction

After experimental use of programmed instruction in the 1920s and 1930s, B. F. Skinner and J.G. Holland first used programmed instruction in behavioral psychology courses at Harvard in the late 1950s. Use of programmed instruction appeared in elementary and secondary schools around the same time. Much of the programmed instruction in American schools was used with individuals or small groups of students and was more often used in junior high schools than senior or elementary schools (Saettler, 1990).

Early use of programmed instruction tended to concentrate on the development of hardware rather than course content. Concerned developers moved away from hardware development to programs based on analysis of learning and instruction based on learning theory. Despite these changes, programmed learning died out in the later part of the 1960s because it did not appear to live up to its original claims (Saettler, 1990).

Individualized Approaches to Instruction

Similar to programmed learning and teaching machines individualized instruction began in the early 1900s, and was revived in the 1960s. The Keller Plan, Individually Prescribed Instruction, Program for Learning in Accordance with Needs, and Individually Guided Education are all examples of individualized instruction in the U.S. (Saettler, 1990).

Keller Plan (1963)

- Developed by F.S. Keller, a colleague of Skinner, the Keller plan was used for university college classes.
- Main features of Keller Plan
    - individually paced.
    - mastery learning.
    - lectures and demonstrations motivational rather than critical information.
    - use of proctors which permitted testing, immediate scoring, tutoring, personal-social aspect of educational process.

      (Saettler, 1990)

Individually Prescribed Instruction (IPI) (1964)

- Developed by Learning Research and Development Center of the University of Pitsburgh.
- Lasted into the 1970s when it lost funding and its use dwindled
- Main features of IPI:
    - prepared units.
    - behavioral objectives.
    - planned instructional sequences.
    - used for reading, math and science.
    - included pretest and posttest for each unit.
    - materials continually evaluated and upgraded to meet behavioral objectives.

  (Saettler, 1990)

Program for Learning in Accordance with Needs (PLAN) (1967)

- Headed by Jon C. Flanagan, PLAN was developed under sponsorship of American Institutes for Research (AIR), Westinghouse Learning Corporation and fourteen U.S. School districts.
- Abandoned in late 1970s because of upgrading costs
- Main features of PLAN
    - schools selected items from about 6,000 behavioral objectives.
    - each instructional module took about two weeks instruction and were made up of approximately. five objectives.
    - mastery learning.
    - remedial learning plus retesting.

  (Saettler, 1990)

Computer-Assisted Instruction (CAI)

Computer-assisted instruction was first used in education and training during the 1950s. Early work was done by IBM and such people as Gordon Pask, and O.M. Moore, but CAI grew rapidly in the 1960s when federal funding for research and development in education and industrial laboratories was implemented. The U.S. government wanted to determine the possible effectiveness of computer-assisted instruction, so they developed two competing companies, (Control Data Corporation and Mitre Corporation) who came up with the PLATO and TICCIT projects. Despite money and research, by the mid seventies it was apparent that CAI was not going to be the success that people had believed. Some of the reasons are:

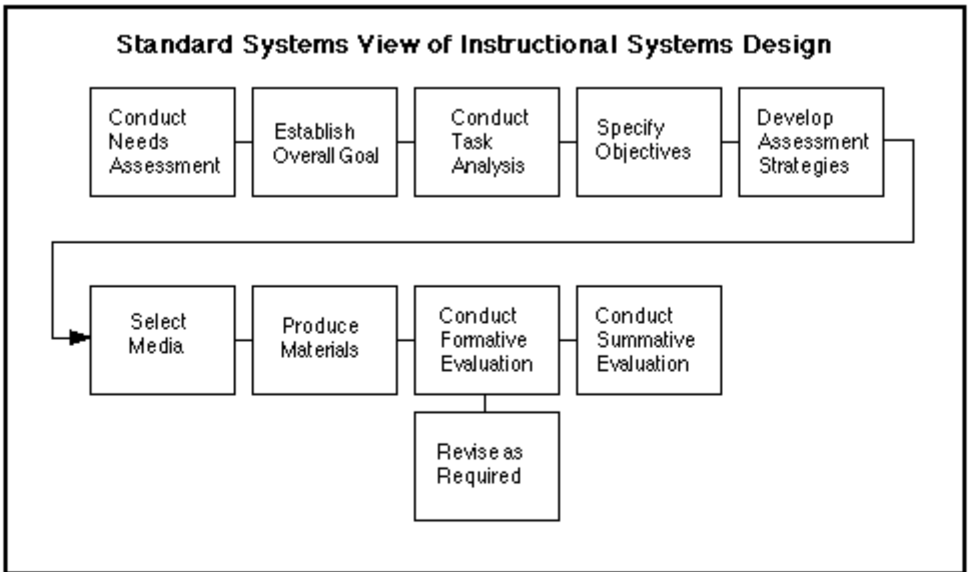
- CAI had been oversold and could not deliver.
- lack of support from certain sectors.
- technical problems in implementation.
- lack of quality software.
- high cost.

Computer-assisted instruction was very much drill-and-practice - controlled by the program developer rather than the learner. Little branching of instruction was implemented although TICCIT did allow the learner to determine the sequence of instruction or to skip certain topics.

(Saettler, 1990)

Systems Approach to Instruction

The systems approach developed out of the 1950s and 1960s focus on language laboratories, teaching machines, programmed instruction, multimedia presentations and the use of the computer in instruction. Most systems approaches are similar to computer flow charts with steps that the designer moves through during the development of instruction. Rooted in the military and business world, the systems approach involved setting goals and objectives, analyzing resources, devising a plan of action and continuous evaluation/modification of the program. (Saettler, 1990)



Shirl S. Schiffman , Instructional Systems Design, Instructional Technology Past Present and Future, Anglin,1995

Cognitivism and Instructional Design

Although cognitive psychology emerged in the late 1950s and began to take over as the dominant theory of learning, it wasn't until the late 1970s that cognitive science began to have its influence on instructional design. Cognitive science began a shift from behavioristic practices which emphasised external behavior, to a concern with the internal mental processes of the mind and how they could be utilized in promoting effective learning. The design models that had been developed in the behaviorist tradition were not simply tossed out, but instead the "task analysis" and "learner analysis" parts of the models were embellished. The new models addressed component processes of learning such as knowledge coding and representation, information storage and retrieval as well as the incorporation and integration of new knowledge with previous information (Saettler, 1990). Because Cognitivism and Behaviorism are both governed by an objective view of the nature of knowledge and what it means to know something, the transition from behavioral instructional design principles to those of a cognitive style was not entirely difficult. The goal of instruction remained the communication or transfer of knowledge to learners in the most efficient, effective manner possible (Bednar et al., in Anglin, 1995). For example, the breaking down of a task into small steps works for a behaviorist who is trying to find the most efficient and fail proof method of shaping a learner's behavior. The cognitive scientist would analyze a task, break it down into smaller steps or chunks and use that information to develop instruction that moves from simple to complex building on prior schema.

The influence of cognitive science in instructional design is evidenced by the use of advance organizers, mnemonic devices, metaphors, chunking into meaningful parts and the careful organization of instructional materials from simple to complex.

Cognitivism and Computer-Based Instruction

Computers process information in a similar fashion to how cognitive scientists believe humans process information: receive, store and retrieve. This analogy makes the possibility of programming a computer to "think" like a person conceivable, i.e.. artificial intelligence.

Artificial intelligence involve the computer working to supply appropriate responses to student input from the computer's data base. A trouble-shooting programs is one example of these programs. Below is a list of some programs and their intended use:

- SCHOLAR - teaches facts about South American geography in a Socratic method
- PUFF - diagnoses medical patients for possible pulmonary disorders
- MYCIN - diagnoses blood infections and prescribes possible treatment
- DENDRAL - enables a chemist to make an accurate guess about the molecular structure of an unknown compound
- META-DENDRAL - makes up its own molecular fragmentation rules in an attempt to explain sets of basic data
- GUIDION - a derivative of the MYCIN program that gave a student information about a case and compared their diagnosis with what MYCIN would suggest
- SOPIE - helps engineers troubleshoot electronic equipment problems
- BUGGY - allows teachers to diagnose causes for student mathematical errors
- LOGO - designed to help children learn to program a computer
- Davis' math programs for the PLATO system - to encourage mathematical development through discovery

  (Saettler, 1990)

Constructivism and Instructional Design

The shift of instructional design from behaviorism to cognitivism was not as dramatic as the move into constructivism appears to be, since behaviorism and cognitivism are both objective in nature. Behaviorism and cognitivism both support the practice of analyzing a task and breaking it down into manageable chunks, establishing objectives, and measuring performance based on those objectives. Constructivism, on the other hand, promotes a more open-ended learning experience where the methods and results of learning are not easily measured and may not be the same for each learner.

While behaviorism and constructivism are very different theoretical perspectives, cognitivism shares some similarities with constructivism. An example of their compatibility is the fact that they share the analogy of comparing the processes of the mind to that of a computer. Consider the following statement by Perkins:

> "...information processing models have spawned the computer model of the mind as an information processor. Constructivism has added that this information processor must be seen as not just shuffling data, but wielding it flexibly during learning -- making hypotheses, testing tentative interpretations, and so on." (Perkins, 1991, p.21 in Schwier, 1998).

Other examples of the link between cognitive theory and constructivism are:

- schema theory (Spiro, et al, 1991, in Schwier, 1998)
- connectionism (Bereiter, 1991, in Schwier, 1998)

- hypermedia (Tolhurst, 1992, in Schwier, 1998)
- multimedia (Dede, 1992, in Schwier, 1998)

Despite these similarities between cognitivism and constructivism, the objective side of cognitivism supported the use of models to be used in the systems approach of instructional design. Constructivism is not compatible with the present systems approach to instructional design, as Jonassen points out :

> "The conundrum that constructivism poses for instructional designers, however, is that if each individual is responsible for knowledge construction, how can we as designers determine and insure a common set of outcomes for leaning, as we have been taught to do?" (Jonasson, [On-line])

In the same article, Jonassen (Jonasson, [On-line]) lists the following implications of constructivism for instructional design:

> "...purposeful knowledge construction may be facilitated by learning environments which:

- Provide multiple representations of reality - avoid oversimplification of instruction by by representing the natural complexity of the world
- Present authentic tasks - contextualize
- Provide real-world, case-based learning environments, rather than pre-determined instructional sequences
- Foster reflective practice
- Enable context- and content-dependent knowledge construction
- Support collaborative construction of knowledge through social negotiation, not competition among learners for recognition

> "Although we believe that constructivism is not a prescriptive theory of instruction, it should be possible to provide more explicit guidelines on how to design learning environments that foster constructivist learning"

Jonassen points out that the difference between constructivist and objectivist, (behavioral and cognitive), instructional design is that objective design has a predetermined outcome and intervenes in the learning process to map a pre-determined concept of reality into the learner's mind, while constructivism maintains that because learning outcomes are not always predictable, instruction should foster, not control, learning. With this in mind, Jonassen looks at the commonalties among constructivist approaches to learning to suggest a "model" for designing constructivist learning environments.

> "...a constructivist design process should be concerned with designing environments which support the construction of knowledge, which ..."

- Is Based on Internal Negotiation
    - a process of articulating mental models, using those models to explain, predict, and infer, and reflecting on their utility (Piaget's accommodation, Norman and Rumelhart's tuning and restructuring.)
- Is Based on Social Negotiation
    - a process of sharing a reality with others using the same or similar processes to those used in internal negotiation
- Is Facilitated by Exploration of Real World Environments and Intervention of New Environments
    - processes that are regulated by each individual's intentions, needs, and/or expectations
- Results in Mental Models and provides Meaningful, Authentic Contexts for Learning and Using the Constructed Knowledge
    - should be supported by case-based problems which have been derived from and situated in the real world with all of its uncertainty and complexity and based on authentic realife practice
- Requires an Understanding of its Own Thinking Process and Problem Solving Methods
    - problems in one context are different from problems in other contexts
- Modeled for Learners by Skilled Performers but Not Necessarily Expert Performers

- Requires Collaboration Among Learners and With the Teacher
  - the teacher is more of a coach or mentor than a purveyor of knowledge
- Provides an Intellectual Toolkit to Facilitate an Internal Negotiation Necessary for Building Mental Models

  (Jonasson, [On-line])

The technological advances of the 1980s and 1990s have enabled designers to move toward a more constructivist approach to design of instruction. One of the most useful tools for the constructivist designer is hypertext and hypermedia because it allows for a branched design rather than a linear format of instruction. Hyperlinks allow for learner control which is crucial to constructivist learning; however, there is some concerns over the novice learner becoming "lost" in a sea of hypermedia. To address this concern, Jonassen and McAlleese (Jonnassen & McAlleese, [On-line]) note that each phase of knowledge acquisition requires different types of learning and that initial knowledge acquisition is perhaps best served by classical instruction with predetermined learning outcomes, sequenced instructional interaction and criterion-referenced evaluation while the more advanced second phase of knowledge acquisition is more suited to a constructivist environment.

If a novice learner is unable to establish an "anchor" in a hypermedia environment they may wander aimlessly through hypermedia becoming completely disoriented. Reigeluth and Chung suggest a prescriptive system which advocates increased learner control. In this method, students have some background knowledge and have been given some instruction in developing their own metacognitive strategies and have some way to return along the path they have taken, should they become "lost". (Davidson, 1998)

Most literature on constructivist design suggests that learners should not simply be let loose in a hypermedia or hypertext environment, but that a mix of old and new (objective and constructive) instruction/learning design be implemented. Davidson's (1998) article, suggesting a criteria for hypermedia learning based on an "exploration of relevant learning theories", is an example of this method.

Having noted the eclectic nature of instructional design, it is only fair to point out that not all theorists advocate a "mix and match" strategy for instructional design. Bednar, Cunningham, Duffy and Perry wrote an article that challenges the eclectic nature if instructional systems design by pointing out that "...abstracting concepts and strategies from the theoretical position that spawned then strips them of their meaning." They question objectivist epistemology completely and have adopted what they consider a constructivist approach to instructional design. In the article they compare the traditional approaches of analysis, synthesis, and evaluation to that of a constructivist approach. (Bednar, Cunningham, Duffy & Perry, 1995)

Learning Theories and the Practice of Instructional Design

What is the difference between the learning theories in terms of the practice of instructional design? Is one approach more easily achieved than another? To address this, one may consider that cognitive theory is the dominant theory in instructional design and many of the instructional strategies advocated and utilized by behaviorists are also used by cognitivists, but for different reasons. For example, behaviorists assess learners to determine a starting point for instruction, while cognitivists look at the learner to determine their predisposition to learning (Ertmer & Newby, 1993). With this in mind, the practice of instructional design can be viewed from a behaviorist/cognitivist approach as opposed to a constructivist approach.

When designing from a behaviorist/cognitivist stance, the designer analyzes the situation and sets a goal. Individual tasks are broken down and learning objectives are developed. Evaluation consists of determining whether the criteria for the objectives has been met. In this approach the designer decides what is important for the learner to know and attempts to transfer that knowledge to the learner. The learning package is somewhat of a closed system, since although it may allow for some branching and remediation, the learner is still confined to the designer's "world".

To design from a constructivist approach requires that the designer produces a product that is much more facilitative in nature than prescriptive. The content is not prespecified, direction is determined by the learner and assessment is much more subjective because it does not depend on specific quantitative criteria, but rather the process and self-evaluation of the learner. The standard pencil-and-paper tests of mastery learning are not used in constructive design; instead, evaluation is based on notes, early drafts, final products and journals. (Assessment [On-line])

Because of the divergent, subjective nature of constructive learning, it is easier for a designer to work from the systems, and thus the objective approach to instructional design. That is not to say that classical instructional design techniques are better than constructive design, but it is easier, less time consuming and most likely less expensive to design within a "closed system" rather than an "open" one. Perhaps there is some truth in the statement that "Constructivism is a 'learning theory', more than a 'teaching approach'." (Wilkinson, 1995)

Learning Theories - Some Strengths and Weaknesses

What are the perceived strengths and weaknesses of using certain theoretical approaches to instructional design?

Behaviorism

Weakness -the learner may find themselves in a situation where the stimulus for the correct response does not occur, therefore the learner cannot respond. - A worker who has been conditioned to respond to a certain cue at work stops production when an anomaly occurs because they do not understand the system.

Strength - the learner is focused on a clear goal and can respond automatically to the cues of that goal. - W.W.II pilots were conditioned to react to silhouettes of enemy planes, a response which one would hope became automatic.

Cognitivism

Weakness - the learner learns a way to accomplish a task, but it may not be the best way, or suited to the learner or the situation. For example, logging onto the internet on one computer may not be the same as logging in on another computer.

Strength - the goal is to train learners to do a task the same way to enable consistency. - Logging onto and off of a workplace computer is the same for all employees; it may be important do an exact routine to avoid problems.

Constructivism

Weakness - in a situation where conformity is essential divergent thinking and action may cause problems. Imagine the fun Revenue Canada would have if every person decided to report their taxes in their own way - although, there probably are some very "constructive" approaches used within the system we have.

Strength - because the learner is able to interpret multiple realities, the learner is better able to deal with real life situations. If a learner can problem solve, they may better apply their existing knowledge to a novel situation.

(Schuman, 1996)

Is There One Best Learning Theory for Instructional Design?

Why bother with Theory at all?

A solid foundation in learning theory is an essential element in the preparation of ISD professionals because it permeates all dimensions of ISD (Shiffman, 1995). Depending on the learners and situation, different learning theories may apply. The instructional designer must understand the strengths and weaknesses of each learning theory to optimize their use in appropriate instructional design strategy. Recipes contained in ID theories may have value for novice designers (Wilson, 1997), who lack the experience and expertise of veteran designers. Theories are useful because they open our eyes to other possibilities and ways of seeing the world. Whether we realize it or not, the best design decisions are most certainly based on our knowledge of learning theories.

An Eclectic Approach to Theory in Instructional Design

The function of ID is more of an application of theory, rather than a theory itself. Trying to tie Instructional Design to one particular theory is like school vs. the real world. What we learn in a school environment does not always match what is out there in the real world, just as the prescriptions of theory do not always apply in practice, (the real world). From a pragmatic point of view, instructional designers find what works and use it.

What Works and How Can We Use It?

Behaviorism, cognitivism and constructivism - what works where and how do we knit everything together to at least give ourselves some focus in our approach to instructional design? First of all we do not need to abandon the systems approach but we must modify it to accommodate constructivist values. We must allow circumstances surrounding the learning situation to help us decide which approach to learning is most appropriate. It is necessary to realize that some learning problems require highly prescriptive solutions, whereas others are more suited to learner control of the environment. (Schwier, 1995)

Jonnassen in *Manifesto for a Constructive Approach to Technology in Higher Education* ([On-line]) identified the following types of learning and matched them with what he believes to be appropriate learning theory approaches.

1. Introductory Learning - learners have very little directly transferable prior knowledge about a skill or content area. They are at the initial stages of schema assembly and integration. At this stage classical instructional design is most suitable because it is predetermined, constrained, sequential and criterion-referenced. The learner can develop some anchors for further exploration.

2. Advanced Knowledge Acquisition - follows introductory knowledge and precedes expert knowledge. At this point constructivist approaches may be introduced.

3. Expertise is the final stage of knowledge acquisition. In this stage the learner is able to make intelligent decisions within the learning environment. A constructivist approach would work well in this case.

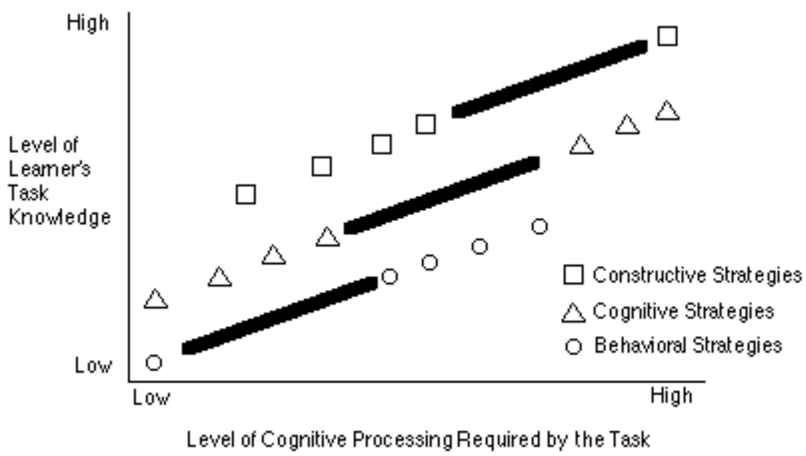
Having pointed out the different levels of learning, Jonassen stresses that it is still important to consider the context before recommending any specific methodology.

Reigeluth's Elaboration Theory which organizes instruction in increasing order of complexity and moves from prerequisite learning to learner control may work in the eclectic approach to instructional design, since the learner can be introduced to the main concepts of a course and then move on to more of a self directed study that is meaningful to them and their particular context.

After having compared and contrasted behaviorism, cognitivism and constructivism, Ertmer and Newby (1993) feel that the instructional approach used for novice learners may not be efficiently stimulating for a learner who is familiar with the content. They do not advocate one single learning theory, but stress that instructional strategy and content addressed depend on the level of the learners. Similar to Jonassen, they match learning theories with the content to be learned:

> ... a **behavioral approach** can effectively facilitate mastery of the content of a profession (knowing what); **cognitive strategies** are useful in teaching problem -solving tactics where defined facts and rules are applied in unfamiliar situations (knowing how); and **constructivist strategies** are especially suited to dealing with ill-defined problems through reflection-in-action. (Ertmer P. & Newby, T., 1993)
>
> **Behavioral**
> ... tasks requiring a low degree of processing (e.g., basic paired associations, discriminations, rote memorization) seem to be facilitated by strategies most frequently associated with a behavioral outlook (e.g., stimulus-response, contiguity of feedback/reinforcement).
>
> **Cognitive**
> Tasks requiring an increased level of processing (e.g., classifications, rule or procedural executions) are primarily associated with strategies
> having a stronger cognitive emphasis (e.g., schematic organization, analogical reasoning, algorithmic problem solving).
>
> **Constructive**
> Tasks demanding high levels of processing (e.g., heuristic problem solving, personal selection and monitoring of cognitive strategies) are frequently
>
> est learned with strategies advanced by the constructivist perspective (e.g., situated learning, cognitive apprenticeships, social negotiation.
>
> (Ertmer P. & Newby, T., 1993)

Ertmer and Newby (1993) believe that the strategies promoted by different learning theories overlap (the same strategy for a different reason) and that learning theory strategies are concentrated along different points of a continuum depending of the focus of the learning theory - the level of cognitive processing required.



Comparison of the associated instructional strategies of the behavioral, cognitive, and constructivist viewpoints based on the learner's level of task knowledge and the level of cognitive processing required by the task.

From Ertmer and Newby: *Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective*

Ertmer and Newby's suggestion that theoretical strategies can complement the learner's level of task knowledge, allows the designer to make the best use of all available practical applications of the different learning theories. With this approach the designer is able to draw from a large number of strategies to meet a variety of learning situations.

Conclusion

Upon completion of this site on learning theories and instructional design, I have not only accomplished my objective, but gained insight and appreciation for the different learning theories and their possible application to instructional design.

It was interesting for me to find that I am not alone in my perspective regarding learning theories and instructional design. There is a place for each theory within the practice of instructional design, depending upon the situation and environment. I especially favor the idea of using an objective approach to provide the learner with an "anchor" before they set sail on the open seas of knowledge. A basic understanding of the material in question provides the learner with a guiding compass for further travel.

Another consideration is the distinction between "training" and "education". In today's competitive business world, the instructional designer may be required to establish and meet the objectives of that business. On the other hand, in a school setting, the designer may be challenged to provide material that fosters an individual to find divergent approaches to problem solving. Whichever situation the instructional designer finds themselves in, they will require a thorough understanding of learning theories to enable them to provide the appropriate learning environment.

Finally, though Instructional Design may have a behaviorist tradition, new insights to the learning process continue to replace, change and alter the process. Advancements in technology make branched constructivist approaches to learning possible. Whether designing for training or education, the instructional designer's toolbox contains an ever changing and increasing number of theoretical applications and physical possibilities. With intelligent application of learning theory strategies and technology, the modern designer will find solutions to the learning requirements of the 21st century.

**Web addresses updated Feb. 5, 2001. Some sites seem to be no longer available, but I am searching for them.

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