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BEHAVIORISM AND INSTRUCTIONAL TECHNOLOGY

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Since the first publication of this chapter in the previous edition of the Handbook, some changes have occurred in the theoretical landscape. Cognitive psychology has moved further away from its roots in information processing toward a stance that emphasizes individual and group construction of knowledge. The notion of the mind as a computer has fallen into disfavor largely due to the mechanistic representation of a human endeavor and the emphasis on the mind–body separation. Actually, these events have made B. F. Skinner's (1974) comments prophetic. Much like Skinner's discussion of use of a machine as a metaphor for human behavior by the logical positivists who believed that "a robot, which behaved precisely like a person, responding in the same way to stimuli, changing its behavior as a result of the same operations, would be indistinguishable from a real person, even though," as Skinner goes on to say, "it would not have feelings, sensations, or ideas." If such a robot could be built, Skinner believed that "it would prove that none of the supposed manifestations of mental life demanded a mentalistic explanation" (p. 16). Indeed, unlike cognitive scientists who explicitly insisted on the centrality of the computer to the understanding of human thought (see, for example, Gardner, 1985), Skinner clearly rejected any characterizations of humans as machines.

In addition, we have seen more of what Skinner (1974) called "the current practice of avoiding" (the mind/body) "dualism by substituting 'brain' for 'mind." Thus, the brain is said to "use data, make hypotheses, make choices, and so on as the mind was once said to have done" (p. 86). In other words, we have seen a retreat from the use of the term "mind" in cognitive psychology. It is no longer fashionable then to posit, as Gardner (1985) did, that "first of all, there is the belief that, in talking about human cognitive activities, it is necessary to speak about mental representations and to posit a level of analysis wholly separate from the biological or neurological on one hand, and the sociological or cultural on the other" (p. 6). This notion of mind, which is separate from nature or nurture, is critical to many aspects of cognitive explanation. By using "brain" instead of "mind," we get the appearance of avoiding the conflict. It is, in fact, an admission of the problem with mind as an explanatory construct, but in no way does it resolve the role that mind was meant to fill.

Yet another hopeful sign is the abandonment of generalities of learning and expertise in favor of an increased role for the stimuli available during learning as well as the feedback that follows (i.e., behavior and consequences). Thus we see more about "situated cognition," "situated learning," "situated knowledge," "cognitive apprenticeships," "authentic materials," etc. (see, for example, Brown, Collins, & Duguid, 1989; Lave, 1988; Lave & Wenger, 1991; Resnick, 1988; Rogoff & Lave, 1984; Suchman, 1987) that evidence an explicit acknowledgment that while behavior "is not 'stimulus bound'. . . nevertheless the environmental ***history*** is still in control; the genetic endowment of the species plus the contingencies to which the individual has been exposed still determine what he will perceive" (Skinner, 1974, p. 82).

Perhaps most importantly, and in a less theoretical vein, has been the rise of distance learning; particularly for those on the bleeding edge of "any time, any place," asynchronous learning. In this arena, issues of scalability, cost effectiveness, maximization of the learner's time, value added, etc. has brought to the forefront behavioral paradigms that had fallen from favor in many circles. A reemergence of technologies such as personalized system instruction (Keller & Sherman, 1974) is clear in the literature. In our last chapter we addressed these models and hinted at their possible use in distance situations. We expand those notions in this current version.

1.1 INTRODUCTION

In 1913, John Watson's *Psychology as the Behaviorist Views it* put forth the notion that psychology did not have to use terms such as consciousness, mind, or images. In a real sense, Watson's work became the opening "round" in a battle that the behaviorists dominated for nearly 60 years. During that period, behavioral psychology (and education) taught little about cognitive concerns, paradigms, etc. For a brief moment, as cognitive psychology eclipsed behavioral theory, the commonalties between the two orientations were evident (see, e.g., Neisser, 1967, 1976). To the victors, however, go the spoils and the rise of cognitive psychology has meant the omission, or in some cases misrepresentation, of behavioral precepts from current curricula. With that in mind, this chapter has three main goals. First, it is necessary to revisit some of the underlying assumptions of the two orientations and review some basic behavioral concepts. Second, we examine the research on instructional technology to illustrate the impact of behavioral psychology on the tools of our field. Finally, we conclude the chapter with an epilogue.

1.2 THE MIND/BODY PROBLEM

> The western mind is European, the European mind is Greek; the Greek mind came to maturity in the city of Athens. (Needham, 1978, p. 98)

The intellectual separation between mind and nature is traceable back to 650 B.C. and the very origins of philosophy itself. It certainly was a centerpiece of Platonic thought by the fourth century B.C. Plato's student Aristotle, ultimately, separated mind from body (Needham, 1978). In modern times, it was René Descartes who reasserted the duality of mind and body and connected them at the pineal gland. The body was made of physical matter that occupied space; the mind was composed of "animal spirits" and its job was to think and control the body. The connection at the pineal gland made your body yours. While it would not be accurate to characterize current cognitivists as Cartesian dualists, it would be appropriate to characterize them as believers of what Churchland (1990) has called "popular dualism" (p. 91); that the "person" or mind is a "ghost in the machine." Current notions often place the "ghost" in a social group. It is this "ghost" (in whatever manifestation) that Watson objected to so strenuously. He saw thinking and hoping as things we *do* (Malone, 1990). He believed that when stimuli, biology, and responses are removed, the residual is not mind, it is nothing. As William James (1904) wrote, ". . . but breath, which was ever the original 'spirit,' breath moving outwards, between the glottis and the nostrils, is, I am persuaded, the essence out of which philosophers have constructed the entity known to them as consciousness" (p. 478).

The view of mental activities as actions (e.g., "thinking is talking to ourself," Watson, 1919), as opposed to their being considered indications of the presence of a consciousness or mind as a separate entity, are central differences between the behavioral and cognitive orientations. According to Malone (1990), the goal of psychology from the behavioral perspective has been clear since Watson:

> We want to predict with reasonable certainty what people will do in specific situations. Given a stimulus, defined as an object of inner or outer experience, what response may be expected? A stimulus could be a blow to the knee or an architect's education; a response could be a knee jerk or the building of a bridge. Similarly, we want to know, given a response, what situation produced it. . . . In all such situations the discovery of the stimuli that call out one or another behavior should allow us to influence the occurrence of behaviors; prediction, which comes from such discoveries, allows control. What does the analysis of conscious experience give us? (p. 97)

Such notions caused Bertrand Russell to claim that Watson made "the greatest contribution to scientific psychology since Aristotle" (as cited in Malone, 1990, p. 96) and others to call him the ". . . simpleton or archfiend . . . who denied the very existence of mind and consciousness (and) reduced us to the status of robots" (p. 96). Related to the issue of mind/body dualism are the emphases on structure versus function and/or evolution and/or selection.

1.2.1 Structuralism, Functionalism, and Evolution

> The battle cry of the cognitive revolution is "mind is back!" A great new science of mind is born. Behaviorism nearly destroyed our concern for it but behaviorism has been overthrown, and we can take up again where the philosophers and early psychologists left off (Skinner, 1989, p. 22)

Structuralism also can be traced through the development of philosophy at least to Democritus' "heated psychic atoms" (Needham, 1978). Plato divided the soul/mind into three distinct components in three different locations: the impulsive/instinctive component in the abdomen and loins, the emotional/spiritual component in the heart, and the intellectual/reasoning component in the brain. In modern times, Wundt at Leipzig and Titchener (his student) at Cornell espoused structuralism as a way of investigating consciousness. Wundt proposed ideas, affect, and impulse and Titchener proposed sensations, images, and affect as the primary elements of consciousness. Titchener eventually identified over 50,000 mental elements (Malone, 1990). Both relied heavily on the method of introspection (to be discussed later) for data. Cognitive notions such as schema, knowledge structures, duplex memory, etc. are structural explanations. There are no behavioral equivalents to structuralism because it is an aspect of mind/consciousness.

Functionalism, however, is a philosophy shared by both cognitive and behavioral theories. Functionalism is associated with John Dewey and William James who stressed the adaptive nature of activity (mental or behavioral) as opposed to structuralism's attempts to separate consciousness into elements. In fact, functionalism allows for an infinite number of physical and mind structures to serve the same functions. Functionalism has its roots in Darwin's *Origin of the Species* (1859), and Wittgenstein's *Philosophical Investigations* (Malcolm, 1954). The question of course is the focus of adaptation: mind or behavior. The behavioral view is that evolutionary forces and adaptations are no different for humans than for the first one-celled organisms; that organisms since the beginning of time have been vulnerable and, therefore, had to learn to discriminate and avoid those things which were harmful and discriminate and approach those things necessary to sustain themselves (Goodson, 1973). This, of course, is the heart of the selectionist position long advocated by B. F. Skinner (1969, 1978, 1981, 1987a, 1987b, 1990).

The selectionist (Chiesa, 1992; Pennypacker, 1994; Vargas, 1993) approach "emphasizes investigating changes in behavioral repertoires over time" (Johnson & Layng, 1992, p. 1475). Selectionism is related to evolutionary theory in that it views the complexity of behavior to be a function of selection contingencies found in nature (Donahoe, 1991; Donahoe & Palmer, 1989; Layng, 1991; Skinner, 1969, 1981, 1990). As Johnson and Layng (1992, p. 1475) point out, this "perspective is beginning to spread beyond the studies of behavior and evolution to the once structuralist-dominated field of computer science, as evidenced by the emergence of parallel distributed processing theory (McClelland & Rumelhart, 1986; Rumelhart & McClelland, 1986), and adaptive networks research (Donahoe, 1991; Donahoe & Palmer, 1989)".

The difficulty most people have in getting their heads around the selectionist position of behavior (or evolution) is that the cause of a behavior is the consequence of a behavior, not the stimulus, mental or otherwise, that precedes it. In evolution, giraffes did not grow longer necks in reaction to higher leaves; rather, a genetic variation produced an individual with a longer neck and *as a consequence* that individual found a niche (higher leaves) that few others could occupy. As a result, that individual survived (was "selected") to breed and the offspring produced survived to breed and in subsequent generations perhaps eventually produced an individual with a longer neck that also survived, and so forth. The radical behaviorist assumes that behavior is selected in exactly that way: by consequences. Of course we do not tend to see the world this way. "We tend to say, often rashly, that if one thing follows another that it was probably caused by it—following the ancient principle of *post hoc, ergo propter hoc* (after this, therefore because of it)" (Skinner, 1974, p. 10). This is the most critical distinction between methodological behaviorism and selectionist behaviorism. The former attributes causality to the stimuli that are antecedent to the behavior, the latter to the consequences that follow the behavior. Methodological behaviorism is in this regard similar to cognitive orientations; the major difference being that the cognitive interpretation would place the stimulus (a thought or idea) inside the head.

1.2.2 Introspection and Constructivism

Constructivism, the notion that meaning (reality) is made, is currently touted as a new way of looking at the world. In fact, there is nothing in any form of behaviorism that requires realism, naive or otherwise. The constructive nature of perception has been accepted at least since von Helmholtz (1866) and his notion of "unconscious inference." Basically, von Helmholtz believed that much of our experience depends upon inferences drawn on the basis of a little stimulation and a lot of past experience. Most, if not all, current theories of perception rely on von Helmholtz's ideas as a base (Malone, 1990). The question is not whether perception is constructive, but what to make of these constructions and where do they come from? Cognitive psychology draws heavily on introspection to "see" the stuff of construction.

In modern times, introspection was a methodological cornerstone of Wundt, Titchener, and the Gestaltist, Kulpe (Malone, 1990). Introspection generally assumes a notion espoused by John Mill (1829) that thoughts are linear; that ideas follow each other one after another. Although it can (and has) been argued that ideas do not flow in straight lines, a much more serious problem confronts introspection on its face. Introspection relies on direct experience; that our "mind's eye" or inner observation reveals things as they are. We know, however, that our other senses do not operate that way.

> The red surface of an apple does not *look* like a matrix of molecules reflecting photons at a certain critical wavelength, but that is what it is. The sound of a flute does not *sound* like a sinusoidal compression wave train in the atmosphere, but that is what it is. The warmth of the summer air does not feel like the mean kinetic energy of millions molecules, but that is what it is. If one's pains and hopes and beliefs do not *introspectively* seem like electrochemical states in a neural network, that may be only because our faculty of introspection, like our other senses, is not sufficiently penetrating to reveal such hidden details. Which is just what we would expect anyway . . . unless we can somehow argue that the faculty of introspection is quite different from all other forms of observation. (Churchland, 1990, p. 15)

Obviously, the problems with introspection became more problematic in retrospective paradigms, that is, when the learner/performer is asked to work from a behavior to a thought. This poses a problem on two counts: accuracy and causality. In terms of accuracy, James Angell stated his belief in his 1907 APA presidential address:

> No matter how much we may talk of the preservation of psychical dispositions, nor how many metaphors we may summon to characterize the storage of ideas in some hypothetical deposit chamber of memory, the obstinate fact remains that when we are not experiencing a

sensation or an idea it is, strictly speaking, non-existent. . . . [W]e have no guarantee that our second edition is really a replica of the first, we have a good bit of presumptive evidence that from the content point of view the original never is and never can be literally duplicated. (Herrnstein & Boring, 1965, p. 502)

The causality problem is perhaps more difficult to grasp at first but, in general, behaviorists have less trouble with "heated" data (self reports of mental activities at the moment of behaving) that reflect "doing in the head" and "doing in the world" at the same time than with going from behavior to descriptions of mental thought, ideas, or structures and *then* saying that the mental activity *caused* the behavioral. In such cases, of course, it is arguably equally likely that the behavioral activities caused the mental activities.

A more current view of constructivism, social constructivism, focuses on the making of meaning through social interaction (e.g., John-Steiner & Mahn, 1996). In the words of Garrison (1994), meanings "are sociolinguistically constructed between two selves participating in a shared understanding" (p. 11). This, in fact, is perfectly consistent with the position of behaviorists (see, for example, Skinner, 1974) as long as this does not also imply the substitution of a group mind of rather than an individual "mind." Garrison, a Deweyan scholar, is, in fact, also a self-proclaimed behaviorist.

1.3 RADICAL BEHAVIORISM

Probably no psychologist in the modern era has been as misunderstood, misquoted, misjudged, and just plain maligned as B. F. Skinner and his Skinnerian, or radical, behaviorism. Much of this stems from the fact that many educational technology programs (or any educational programs, for that matter) do not teach, at least in any meaningful manner, behavioral theory and research. More recent notions such as cognitive psychology, constructivism, and social constructivism have become "featured" orientations. Potentially worse, recent students of educational technology have not been exposed to course work that emphasized history and systems, or theory building and theory analysis. In terms of the former problem, we will devote our conclusion to a brief synopsis of what radical behaviorism is and what it isn't. In terms of the latter, we will appeal to the simplest of the criteria for judging the adequacy and appropriateness of a theory: parsimony.

1.3.1 What Radical Behaviorism Does Not Believe

It is important to begin this discussion with what radical behaviorism rejects: structuralism (mind–body dualism), operationalism, and logical positivism.

That radical behaviorism rejects structuralism has been discussed earlier in the introduction of this article. Skinner (1938, 1945, 1953b, 1957, 1964, 1974) continually argued against the use of structures and mentalisms. His arguments are too numerous to deal with in this work, but let us consider what is arguably the most telling: copy theory. "The most important consideration is that this view presupposes three things: (a) a stimulus object in the external world, (b) a sensory registering of that object via some modality, and (c) the internal representation of that object as a sensation, perception or image, different from (b) above. The first two are physical and the third, presumably something else" (Moore, 1980, p. 472–473).

In Skinner's (1964) words:

The need for something beyond, and quite different from, copying is not widely understood. Suppose someone were to coat the occipital lobes of the brain with a special photographic emulsion which, when developed, yielded a reasonable copy of a current visual stimulus. In many quarters, this would be regarded as a triumph in the physiology of vision. Yet nothing could be more disastrous, for we should have to start all over again and ask how the organism sees a picture in its occipital cortex, and we should now have much less of the brain available from which to seek an answer. It adds nothing to an explanation of how an organism reacts to a stimulus to trace the pattern of the stimulus into the body. It is most convenient, for both organism and psychophysiologist, if the external world is never copied—if the world we know is simply the world around us. The same may be said of theories according to which the brain interprets signals sent to it and in some sense reconstructs external stimuli. If the real world is, indeed, scrambled in transmission but later reconstructed in the brain, we must then start all over again and explain how the organism sees the reconstruction. (p. 87)

Quite simply, if we copy what we see, what do we "see" the copy with and what does this "mind's eye" do with its input? Create another copy? How do we, to borrow from our information processing colleagues, exit this recursive process?

The related problem of mentalisms generally, and their admission with the dialog of psychology on largely historical grounds was also discussed often by Skinner. For example:

Psychology, alone among the biological and social sciences, passed through a revolution comparable in many respects with that which was taking place at the same time in physics. This was, of course, behaviorism. The first step, like that in physics, was a reexamination of the observational bases of certain important concepts . . . Most of the early behaviorists, as well as those of us just coming along who claimed some systematic continuity, had begun to see that psychology did not require the redefinition of subjective concepts. The reinterpretation of an established set of explanatory fictions was not the way to secure the tools then needed for a scientific description of behavior. Historical prestige was beside the point. There was no more reason to make a permanent place for "consciousness," "will," "feeling," and so on, than for "phlogiston" or "vis anima." On the contrary, redefined concepts proved to be awkward and inappropriate, and Watsonianism was, in fact, practically wrecked in the attempt to make them work.

Thus it came about while the behaviorists might have applied Bridgman's principle to representative terms from a mentalistic psychology (and were most competent to do so), they had lost all interest in the matter. They might as well have spent their time in showing what an eighteenth century chemist was talking about when he said that the Metallic Substances consisted of a vitrifiable earth united with phlogiston. There was no doubt that such a statement could be analyzed operationally or translated into modern terms, or that subjective terms could be operationally defined. But such matters were of historical interest only. What was wanted was a fresh set of concepts derived from a direct analysis of newly emphasized data . . . (p. 292)

Operationalism is a term often associated with Skinnerian behaviorism and indeed in a sense this association is correct; not, however, in the historical sense of operationalism of Stevens (1939) or, in his attacks on behaviorism, by Spence (1948), or in the sense that it is assumed today: "how to deal scientifically with mental events" (Moore, 1980, p. 571). Stevens (1951) for example, states that "operationalism does not deny images, for example, but asks: What is the operational definition of the term "image?" (p. 231). As Moore (1981) explains, this "conventional approach entails virtually every aspect of the dualistic position" (p. 470). "In contrast, for the radical behaviorist, operationalism involves the functional analysis of the term in question, that is, an assessment of the discriminative stimuli that occasions the use of the term and the consequences that maintain it" (Moore, 1981, p. 59). In other words, radical behaviorism rejects the operationalism of methodology behaviorists, but embraces the operationalism implicit in the three-part contingency of antecedents, behaviors, and consequences and would, in fact, apply it to the social dialog of scientists themselves!

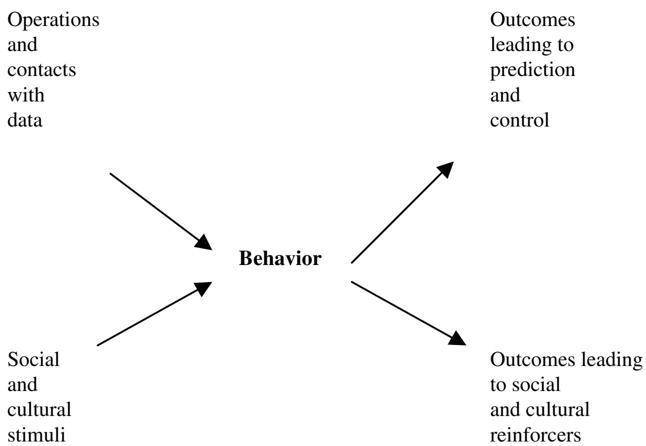
The final demon to deal with is the notion that radical behaviorism somehow relies on logical positivism. This rejection of this premise will be dealt with more thoroughly in the section to follow that deals with social influences, particularly social influences in science. Suffice it for now that Skinner (1974) felt that methodological behaviorism and logical positivism "ignore consciousness, feelings, and states of mind" but that radical behaviorism does not thus "behead the organism . . . it was not designed to 'permit consciousness to atrophy'" (p. 219). Day (1983) further describes the effect of Skinner's 1945 paper at the symposium on operationalism. "Skinner turns logical positivism upside down, while methodological behaviorism continues on its own, particular logical-positivist way" (p. 94).

1.3.2 What Radical Behaviorism Does Believe

Two issues which Skinnerian behaviorism is clear on, but not apparently well understood but by critics, are the roles of private events and social/cultural influences. The first problem, radical behaviorism's treatment of private events, relates to the confusion on the role of operationalism: "The position that psychology must be restricted to publicly observable, intersubjectively, verifiable data bases more appropriately characterizes what Skinner calls methodological behaviorism, an intellectual position regarding the admissibility of psychological data that is conspicuously linked to logical positivism and operationalism" (Moore, 1980, p. 459). Radical behaviorism holds as a central tenet that to rule out stimuli because they are not accessible to others not only represents inappropriate vestiges of operationalism and positivism, it compromises the explanatory integrity of behaviorism itself (Skinner, 1953a, 1974). In fact, radical behaviorism does not only value private events, it says they are the same as public events, and herein lies the problem, perhaps. Radical behaviorism does not believe it is necessary to suppose that private events have any special properties simply because they are private (Skinner, 1953b). They are distinguished only by their limited accessibility, but are assumed to be equally lawful as public events (Moore, 1980). In other words, the same analyses should be applied to private events as public ones. Obviously, some private, or covert, behavior involves the same musculature as the public or overt behavior as in talking to oneself or "mental practice" of a motor event (Moore, 1980). Generally, we assume private behavior began as a public event and then, for several reasons, became covert. Moore gives three examples of such reasons. The first is convenience: We learn to read publicly, but private behavior is faster. Another case is that we can engage in a behavior privately and if the consequences are not suitable, reject it as a public behavior. A second reason is to avoid aversive consequences. We may sing a song over and over covertly but not sing it aloud because we fear social disapproval. Many of us, alone in our shower or in our car, with the negative consequences safely absent, however, may sing loudly indeed. A third reason is that the stimuli that ordinarily elicit an overt behavior are weak and deficient. Thus we become "unsure" of our response. We may think we see something, but be unclear enough to either not say anything or make a weak, low statement.

What the radical behaviorist does not believe is that private behaviors *cause* public behavior. Both are assumed to be attributable to common variables. The private event may have some discrimination stimulus control, but this is not the cause of the subsequent behavior. The cause is the contingencies of reinforcement that control both public and private behavior (Day, 1976). It is important, particularly in terms of current controversy, to point out that private events are in no way superior to public events and in at least one respect important to our last argument, very much inferior: the verbal (social) community has trouble responding to these (Moore, 1980). This is because the reinforcing consequence "in most cases is social attention" (Moore, 1980, p. 461).

The influence of the social group, of culture, runs through all of Skinner's work (see, e.g., Skinner, 1945, 1953b, 1957, 1964, 1974). For this reason, much of this work focuses on language. As a first step (and to segué from private events), consider an example from Moore (1980). The example deals with pain, but feel free to substitute any private perception. Pain is clearly a case where the stimulus is only available to the individual who perceives it (as opposed to most events which have some external correlate). How do we learn to use the verbal response to pain appropriately? One way is for the individual to report pain after some observable public event such as falling down, being struck, etc. The verbal community would support a statement of pain and perhaps suggest that sharp objects cause sharp pain, dull objects, dull pain. The second case would involve a collateral, public response such as holding the area in pain. The final case would involve using the word pain in connection with some overt state of affairs such as a bent back, or a stiff neck. It is important to note that if the individual reports pain too often *without* such overt signs, he or she runs the risk of being called a hypochondriac or malingerer (Moore, 1980). "Verbal behavior, is a social phenomenon, and so in a sense all verbal behavior, including scientific verbal behavior is a product of social–cultural influences" (Moore, 1984, p. 75). To examine the key role of social cultural influences it is useful to use an example we are familiar with, science. As Moore (1984) points out, "Scientists typically live the first 25 years of their lives, and 12 to 16 hours per day thereafter, in the lay community" (p. 61). Through the process of social and cultural reinforcers, they become acculturated and as a result are exposed to popular preconceptions. Once the individual becomes a scientist, operations and contact with data cue behaviors which lead to prediction and control. The two systems cannot operate separately. In fact, the behavior of the scientist may be understood as a product of the conjoint action of scientific and lay discriminative stimuli and scientific and lay reinforcer (Moore, 1984). Thus, from Moore:



Although it is dangerous to focus too hard on the "data" alone, Skinner (1974) also cautions against depending exclusively on the social/cultural stimuli and reinforcers for explanations, as is often the case with current approaches.

> Until fairly late in the nineteenth century, very little was known about the bodily processes in health or disease from which good medical practice could be derived, yet a person who was ill should have found it worthwhile to call in a physician. Physicians saw many ill people and were in the best possible position to acquire useful, if unanalyzed, skills in treating them. Some of them no doubt did so, but the history of medicine reveals a very different picture. Medical practices have varied from epoch to epoch, but they have often consisted of barbaric measures—blood lettings, leechings, cuppings, poultices, emetics, and purgations—which more often than not must have been harmful. Such practices were not based on the skill and wisdom acquired from contact with illness; they were based on theories of what was going on inside the body of a person who was ill. . . .
>
> Medicine suffered, and in part just because the physician who talked about theories seemed to have a more profound knowledge of illness than one who merely displayed the common sense acquired from personal experience. The practices derived form theories no doubt also obscured many symptoms which might have led to more effective skills. Theories flourished at the expense both of the patient and of progress toward the more scientific knowledge which was to emerge in modern medicine. (Skinner, 1974, pp. x–xi)

1.4 THE BASICS OF BEHAVIORISM

Behaviorism in the United States may be traced to the work of E. B. Twitmeyer (1902), a graduate student at the University of Pennsylvania, and E. L. Thorndike (1898). Twitmeyer's doctoral dissertation research on the knee-jerk (patellar) reflex involved alerting his subjects with a bell that a hammer was about to strike their patellar tendon. As has been the case so many times in the history of the development of behavioral theory (see, for example, Skinner, 1956), something went wrong. Twitmeyer sounded the bell but the hammer did not trip. The subject, however, made a knee-jerk response in *anticipation* of the hammer drop. Twitmeyer redesigned his experiment to study this phenomenon and presented his findings at the annual meeting of the American Psychological Association in 1904. His paper, however, was greeted with runaway apathy and it fell to Ivan Pavlov (1849–1936) to become the "Father of Classical Conditioning." Interestingly enough, Pavlov also began his line of research based on a casual or accidental observation. A Nobel Prize winner for his work in digestion, Pavlov noted that his subjects (dogs) seemed to begin salivating to the sights and sounds of feeding. He, too, altered the thrust of his research to investigate his serendipitous observations more thoroughly.

Operant or instrumental conditioning is usually associated with B. F. Skinner. Yet, in 1898, E. L. Thorndike published a monograph on animal intelligence which made use of a "puzzle box" (a forerunner of what is often called a "Skinner Box") to investigate the effect of reward (e.g., food, escape) on the behavior of cats. Thorndike placed the cats in a box that could be opened by pressing a latch or pulling a string. Outside the box was a bowl of milk or fish. Not surprisingly, the cats tried anything and everything until they stumbled onto the correct response. Also, not surprisingly, the cats learned to get out of the box more and more rapidly. From these beginnings, the most thoroughly researched phenomenon in psychology evolves.

Behavioral theory is now celebrating nearly a century of contribution to theories of learning. The pioneering work of such investigators as Cason (1922a, 1922b), Liddell (1926), Mateer (1918), and Watson and Rayner (1920) in classical conditioning, and Blodgett (1929), Hebb (1949), Hull (1943), and Skinner (1938) in operant conditioning, has led to the development of the most powerful technology known to behavioral science. Behaviorism, however, is in a paradoxical place in American education today. In a very real sense, behavioral theory is the basis for innovations such as teaching machines, computer-assisted instruction, competency-based education (mastery learning), instructional design, minimal competency testing, performance-based assessment, "educational accountability," situated cognition, and even social constructivism, yet behaviorism is no longer a "popular" orientation in education or instructional design. An exploration of behaviorism, its contributions to research and current practice in educational technology (despite its recent unpopularity), and its usefulness in the future are the concerns of this chapter.

1.4.1 Basic Assumptions

Behavioral psychology has provided instructional technology with several basic assumptions, concepts, and principles. These components of behavioral theory are outlined in this section (albeit briefly) in order to ensure that the discussion of its applications can be clearly linked back to the relevant behavioral theoretical underpinnings. While some or much of the following discussion may be elementary for many, we believed it was crucial to lay the groundwork that illustrates the major role behavioral psychology has played and *continues* to play in the research and development of instructional technology applications.

Three major assumptions of selectionist behaviorism are directly relevant to instructional technology. These assumptions focus on the following: the role of the learner, the nature of learning, and the generality of the learning processes and instructional procedures.

1.4.1.1 The Role of the Learner. As mentioned earlier in this chapter, one of the most misinterpreted and misrepresented assumptions of behavioral learning theory concerns the role of the learner. Quite often, the learner is characterized as a passive entity that merely reacts to environmental stimuli (cf., Anderson's receptive–accrual model, 1986). However, according to B. F. Skinner, knowledge is action (Schnaitter, 1987). Skinner (1968) stated that a learner "does not passively absorb knowledge from the world around him but must play an active role" (p. 5). He goes on to explain how learners learn by doing, experiencing, and engaging in trial and error. All three of these components work together and must be studied together to formulate any given instance of learning. It is only when these three components are describable that we can identify what has been learned, under what conditions the learning has taken place, and the consequences that support and maintain the learned behavior. The emphasis is on the active responding of the learner—the learner must be engaged in the behavior in order to learn and to validate that learning has occurred.

1.4.1.2 The Nature of Learning. Learning is frequently defined as a change in behavior due to experience. It is a function of building associations between the occasion upon which the behavior occurs (stimulus events), the behavior itself (response events) and the result (consequences). These associations are centered in the experiences that produce learning, and differ to the extent to which they are contiguous and contingent (Chance, 1994). Contiguity refers to the close pairing of stimulus and response in time and/or space. Contingency refers to the dependency between the antecedent or behavioral event and either the response or consequence. Essential to the strengthening responses with these associations is the repeated continuous pairing of the stimulus with response and the pairing consequences (Skinner, 1968). It is the construction of functional relationships, based on the contingencies of reinforcement, under which the learning takes place. It is this functionality that is the essence of selection. Stimulus control develops as a result of continuous pairing with consequences (functions). In order to truly understand what has been learned, the entire relationship must be identified (Vargas, 1977). All components of this three-part contingency (i.e., functional relationship) must be observable and measurable to ensure the scientific verification that learning (i.e., a change of behavior) has occurred (Cooper, Heron, & Heward, 1987).

Of particular importance to instructional technology is the need to focus on the individual in this learning process. Contingencies vary from person to person based on each individual's genetic and reinforcement histories and events present at the time of learning (Gagné, 1985). This requires designers and developers to ensure that instruction is aimed at aiding the learning of the individual (e.g., Gagné, Briggs, & Wager, 1992). To accomplish this, a needs assessment (Burton & Merrill, 1991) or front-end analysis (Mager, 1984; Smith & Ragan, 1993) is conducted at the very beginning of the instructional design process. The focus of this activity is to articulate, among other things, learner characteristics; that is, the needs and capabilities of individual learners are assessed to ensure that the instruction being developed is appropriate and meaningful. The goals are then written in terms of what the learner will accomplish via this instructional event.

The material to be learned must be identified in order to clearly understand the requisite nature of learning. There is a natural order inherent in many content areas. Much of the information within these content areas is characterized in sequences; however, many others form a network or a tree of related information (Skinner, 1968). (Notice that in the behavioral views, such sequences or networks do not imply internal structures; rather, they suggest a line of attack for the designs). Complex learning involves becoming competent in a given field by learning incremental behaviors which are ordered in these sequences, traditionally with very small steps, ranging from the most simple to more complex to the final goal. Two major considerations occur in complex learning. The first, as just mentioned, is the gradual elaboration of extremely complex patterns of behavior. The second involves the maintenance of the behavior's strength through the use of reinforcement contingent upon successful achievement at each stage. Implicit in this entire endeavor is the observable nature of actual learning public performance which is crucial for the acknowledgment, verification (by self and/or others), and continued development of the present in similar behaviors.

1.4.1.3 The Generality of Learning Principles. According to behavioral theory, all animals—including humans—obey universal laws of behavior (a.k.a., equipotentiality) (Davey, 1981). In methodological behaviorism, all habits are formed from conditioned reflexes (Watson, 1924). In selectionist behaviorism, all learning is a result of the experienced consequences of the organisms' behavior (Skinner, 1971). While Skinner (1969) does acknowledge species-specific behavior (e.g., adaptive mechanisms, differences in sensory equipment, effector systems, reactions to different reinforcers), he stands by the fact that the basic processes that promote or inhibit learning are universal to all organisms. Specifically, he states that the research does show an

> . . . extraordinary uniformity over a wide range of reinforcement, the processes of extinction, discrimination and generalization return remarkably similar and consistent results across species. For example, fixed-interval reinforcement schedules yield a predictable scalloped performance effect (low rates of responding at the beginning of the interval following reinforcement, high rates of responding at the end of the

interval) whether the subjects are animals or humans. (Ferster & Skinner, 1957, p. 7)

Most people of all persuasions will accept behaviorism as an account for much, even most, learning (e.g., animal learning and perhaps learning up to the alphabet or shoe tying or learning to speak the language). For the behaviorist, the same principles that account for simple behaviors also account for complex ones.

1.4.2 Basic Concepts and Principles

Behavioral theory has contributed several important concepts and principles to the research and development of instructional technology. Three major types of behavior, respondent learning, operant learning, and observational learning, serve as the organizer for this section. Each of these models relies on the building associations—the simplest unit that is learned—under the conditions of contiguity and repetition (Gagné, 1985). Each model also utilizes the processes of discrimination and generalization to describe the mechanisms humans use to adapt to situational and environmental stimuli (Chance, 1994). Discrimination is the act of responding differently to different stimuli, such as stopping at a red traffic light while driving through a green traffic light. Generalization is the act of responding in the same way to similar stimuli, specifically, to those stimuli not present at time of training. For example, students generate classroom behavior rules based on previous experiences and expectations in classroom settings. Or, when one is using a new word processing program, the individual attempts to apply what is already known about a word processing environment to the new program. In essence, discrimination and generalization are inversely related, crucial processes that facilitate adaptation and enable transfer to new environments.

1.4.2.1 Respondent Learning (Methodological Behaviorism). Involuntary actions, called respondents, are entrained using the classical conditioning techniques of Ivan Pavlov. In classical conditioning, an organism learns to respond to a stimulus that once prompted no response. The process begins with identification and articulation of an unconditional stimulus (US) that automatically elicits an emotional or physiological unconditional response (UR). No prior learning or conditioning is required to establish this natural connection (e.g., US = food; UR = salivation). In classical conditioning, neutral stimulus is introduced, which initially prompts no response from the organism (e.g., a tone). The intent is to eventually have the tone (i.e., the conditioned stimulus or CS) elicit a response that very closely approximates the original UR (i.e., will become the conditional response or CR). The behavior is entrained using the principles of contiguity and repetition (i.e., practice). In repeated trials, the US and CS are introduced at the same time or in close temporal proximity. Gradually the US is presented less frequently with the CS, being sure to retain the performance of the UR/CR. Ultimately, the CS elicits the CR without the aid of the US.

Classical conditioning is a very powerful tool for entraining basic physiological responses (e.g., increases in blood pressure, taste aversions, psychosomatic illness), and emotive responses (e.g., arousal, fear, anxiety, pleasure) since the learning is paired with reflexive, inborn associations. Classical conditioning is a major theoretical notion underlying advertising, propaganda, and related learning. Its importance in the formations of biases, stereotypes, etc. is of particular importance in the design of instructional materials and should always be considered in the design process.

The incidental learning of these responses is clearly a concern in instructional settings. Behaviors such as test anxiety and "school phobia" are maladaptive behaviors that are often entrained without intent. From a proactive stance in instructional design, a context or environmental analysis is a key component of a needs assessment (Tessmer, 1990). Every feature of the physical (e.g., lighting, classroom arrangement) and support (e.g., administration) environment are examined to ascertain positive or problematic factors that might influence the learner's attitude and level of participation in the instructional events. Similarly, in designing software, video, audio, and so forth, careful attention is paid to the aesthetic features of the medium to ensure motivation and engagement. Respondent learning is a form of methodological behaviorism to be discussed later.

1.4.2.2 Operant Conditioning (Selectionist or Radical Behaviorism). Operant conditioning is based on a single, simple principle: There is a functional and interconnected relationship between the stimuli that preceded a response (antecedents), the stimuli that follow a response (consequences), and the response (operant) itself. Acquisition of behavior is viewed as resulting from these three-term or three-component contingent or functional relationships. While there are always contingencies in effect which are beyond the teacher's (or designer's) control, it is the role of the educator to control the environment so that the predominant contingent relationships are in line with the educational goal at hand.

Antecedent cues. Antecedents are those objects or events in the environment that serve as cues. Cues set the stage or serve as signals for specific behaviors to take place because such behaviors have been reinforced in the past in the presence of such cues. Antecedent cues may include temporal cues (time), interpersonal cues (people), and covert or internal cues (inside the skin). Verbal and written directions, nonverbal hand signals and facial gestures, highlighting with colors and boldfaced print are all examples of cues used by learners to discriminate the conditions for behaving in a way that returns a desired consequence. The behavior ultimately comes under stimulus "control" (i.e., made more probable by the discriminative stimulus or cue) though the contiguous pairing in repeated trials, hence serving in a key functional role in this contingent relationship. Often the behavioral technologist seeks to increase or decrease antecedent (stimulus) control to increase or decrease the probability of a response. In order to do this, he or she must be cognizant of those cues to which generalized responding is desired or present and be aware that antecedent control will increase with consequence pairing.

Behavior. Unlike the involuntary actions entrained via classical conditioning, most human behaviors are emitted or voluntarily enacted. People deliberately "operate" on their environment to produce desired consequences. Skinner termed these purposeful *responses operants*. Operants include both private (thoughts) and public (behavior) activities, but the basic measure in behavioral theory remains the observable, measurable response. Operants range from simple to complex, verbal to nonverbal, fine to gross motor actions—the whole realm of what we as humans choose to do based on the consequences the behavior elicits.

Consequences. While the first two components of operant conditioning (antecedents and operants) are relatively straightforward, the nature of *consequences* and interactions between consequences and behaviors is fairly complex. First, consequences may be classified as contingent and noncontingent. Contingent consequences are reliable and relatively consistent. A clear association between the operant and the consequences can be established. Noncontingent consequences, however, often produce accidental or superstitious conditioning. If, perchance, a computer program has scant or no documentation and the desired program features cannot be accessed via a predictable set of moves, the user would tend to press many keys, not really knowing what may finally cause a successful screen change. This reduces the rate of learning, if any learning occurs at all.

Another dimension focuses on whether or not the consequence is actually delivered. Consequences may be positive (something is presented following a response) or negative (something is taken away following a response). Note that positive and negative do not imply value (i.e., "good" or "bad"). Consequences can also be reinforcing, that is, tend to maintain or increase a behavior, or they may be punishing, that is, tend to decrease or suppress a behavior. Taken together, the possibilities then are positive reinforcement (presenting something to maintain or increase a behavior); positive punishment (presenting something to decrease a behavior); negative reinforcement (taking away something to increase a behavior); or negative punishment (taking away something to decrease a behavior). Another possibility obviously is that of no consequence following a behavior, which results in the disappearance or extinction of a previously reinforced behavior.

Examples of these types of consequences are readily found in the implementation of behavior modification. Behavior modification or applied behavior analysis is a widely used instructional technology that manipulates the use of these consequences to produce the desired behavior (Cooper et al., 1987). Positive reinforcers ranging from praise, to desirable activities, to tangible rewards are delivered upon performance of a desired behavior. Positive punishments such as extra work, physical exertion, demerits are imposed upon performance of an undesirable behavior. Negative reinforcement is used when aversive conditions such as a teacher's hard gaze or yelling are taken away when the appropriate behavior is enacted (e.g., assignment completion). Negative punishment or response cost is used when a desirable stimulus such as free time privileges are taken away when an inappropriate behavior is performed. When no consequence follows the behavior, such as ignoring an undesirable behavior, ensuring that no attention is given to the misdeed, the undesirable behavior often abates. But this typically is preceded by an upsurge in the frequency of responding until the learner realizes that the behavior will no longer receive the desired consequence. All in all, the use of each consequence requires consideration of whether one wants to increase or decrease a behavior, if it is to be done by taking away or giving some stimulus, and whether or not that stimulus is desirable or undesirable.

In addition to the type of consequence, the schedule for the delivery or timing of those consequences is a key dimension to operant learning. Often a distinction is made between simple and complex *schedules of reinforcement.* Simple schedules include continuous consequation and partial or intermittent consequation. When using a continuous schedule, reinforcement is delivered after each correct response. This procedure is important for the learning of new behaviors because the functional relationship between antecedent–response–consequence is clearly communicated to the learner through predictability of consequation.

When using intermittent schedules, the reinforcement is delivered after some, but not all, responses. There are two basic types of intermittent schedules: ratio and interval. A ratio schedule is based on the numbers of responses required for consequation (e.g., piece work, number of completed math problems). An interval schedule is based on the amount of time that passes between consequation (e.g., payday, weekly quizzes). Ratio and interval schedules may be either fixed (predictable) or variable (unpredictable). These procedures are used once the functional relationship is established and with the intent is to encourage persistence of responses. The schedule is gradually changed from continuous, to fixed, to variable (i.e., until it becomes very "lean"), in order for the learner to perform the behavior for an extended period of time without any reinforcement. A variation often imposed on these schedules is called limited hold, which refers to the consequence only being available for a certain period of time.

Complex schedules are composed of the various features of simple schedules. Shaping requires the learner to perform successive approximations of the target behavior by changing the criterion behavior for reinforcement to become more and more like the final performance. A good example of shaping is the writing process, wherein drafts are constantly revised toward the final product. Chaining requires that two or more learned behaviors must be performed in a specific sequence for consequation. Each behavior sets up cues for subsequent responses to be performed (e.g., long division). In multiple schedules, two or more simple schedules are in effect for the same behavior with each associated with a particular stimulus. Two or more schedules are available in a concurrent schedule procedure; however, there are no specific cues as to which schedule is in effect. Schedules may also be conjunctive (two or more behaviors that all must be performed for consequation to occur, but the behaviors may occur in any order), or tandem (two or more behaviors must be performed in a specific sequence without cues).

In all cases, the schedule or timing of the consequation is manipulated to fit the target response, using antecedents to signal the response, and appropriate consequences for the learner and the situation.

1.4.2.3 Observational Learning. By using the basic concepts and principles of operant learning, and the basic definition that learning is a change of behavior brought about by experience, organisms can be thought of as learning new behaviors by observing the behavior of others (Chance, 1994). This premise was originally tested by Thorndike (1898) with cats, chicks, and dogs, and later by Watson (1908) with monkeys, without success. In all cases, animals were situated in positions to observe and learn elementary problem-solving procedures (e.g., puzzle boxes) by watching successful same-species models perform the desired task. However, Warden and colleagues (Warden, Field, & Koch, 1940; Warden, Jackson, 1935) found that when animals were put in settings (e.g., cages) that were identical to the modeling animals and the observers watched the models perform the behavior and receive the reinforcement, the observers did learn the target behavior, often responding correctly on the first trial (Chance, 1994).

Attention focused seriously on observational learning research with the work of Bandura and colleagues in the 1960s. In a series of studies with children and adults (with children as the observers and children and adults as the models), these researchers demonstrated that the reinforcement of a model's behavior was positively correlated with the observer's judgments that the behavior was appropriate to imitate. These studies formed the empirical basis for Bandura's (1977) Social Learning Theory, which stated that people are not driven by either inner forces or environmental stimuli in isolation. His assertion was that behavior and complex learning must be "explained in terms of a continuous reciprocal interaction of personal and environmental determinants . . . virtually all learning phenomenon resulting from direct experience occur on a vicarious basis by observing other people's behavior and its consequences for them" (p. 11–12).

The basic observational or vicarious learning experience consists of watching a live or filmed performance or listening to a description of the performance (i.e., symbolic modeling) of a model and the positive and/or negative consequences of that model's behavior. Four component processes govern observational learning (Bandura, 1977). First, *attentional processes* determine what is selectively observed, and extracted valence, complexity, prevalence, and functional value influence the quality of the attention. Observer characteristics such as sensory capacities, arousal level, perceptual set, and past reinforcement history mediate the stimuli. Second, the attended stimuli must be remembered or retained (i.e., *retentional processes*). Response patterns must be represented in memory in some organized, symbolic form. Humans primarily use imaginal and verbal codes for observed performances. These patterns must be practiced through overt or covert rehearsal to ensure retention. Third, the learner must engage in *motor reproduction processes* which require the organization of responses through their initiation, monitoring, and refinement on the basis of feedback. The behavior must be performed in order for cues to be learned and corrective adjustments made. The fourth component is *motivation*. Social learning theory recognizes that humans are more likely to adopt behavior that they value (functional) and reject behavior that they find punishing or unrewarding (not functional). Further, the evaluative judgments that humans make about the functionality of their own behavior mediate and regulate which observationally learned responses they will actually perform. Ultimately, people will enact self-satisfying behaviors and avoid distasteful or disdainful ones. Consequently, external reinforcement, vicarious reinforcement, and self-reinforcement are all processes that promote the learning and performance of observed behavior.

1.4.3 Complex Learning, Problem Solving, and Transfer

Behavioral theory addresses the key issues of complex learning, problem solving, and transfer using the same concepts and principles found in the everyday human experience. Complex learning is developed through the learning of chained behaviors (Gagné, 1985). Using the basic operant conditioning functional relationship, through practice and contiguity, the consequence takes on a dual role as the stimulus for the subsequent operant. Smaller chainlike skills become connected with other chains. Through discrimination, the individual learns to apply the correct chains based on the antecedent cues. Complex and lengthy chains, called procedures, continually incorporate smaller chains as the learner engages in more practice and receives feedback. Ultimately, the learner develops organized, and smooth performance characterized with precise timing and applications.

Problem solving represents the tactical readjustment to changes in the environment based on trial and error experiences (Rachlin, 1991). Through the discovery of a consistent pattern of cues and a history of reinforced actions, individuals develop strategies to deal with problems that assume a certain profile of characteristics (i.e., cues). Over time, responses occur more quickly, adjustments are made based on the consequences of the action, and rule-governed behavior develops (Malone, 1990).

Transfer involves the replication of identical behaviors from a task that one learns in an initial setting to a new task that has similar elements (Mayer & Wittrock, 1996). The notion of specific transfer or "theory of identical elements" was proposed by Thorndike and his colleagues (e.g., Thorndike, 1924; Thorndike & Woodworth, 1901). Of critical importance were the "gradients of similarity along stimulus dimensions" (Greeno, Collins, & Resnick, 1996). That is, the degree to which a response generalizes to stimuli other than the original association is dependent upon the similarity of other stimuli in terms of specific elements: The more similar the new stimulus, the higher probability of transfer. Critical to this potential for transfer were the strength of the specific associations, similarity of antecedent cues, and drill and practice on the specific skills with feedback.

1.4.4 Motivation

From a behavioral perspective, willingness to engage in a task is based on extrinsic motivation (Greeno et al., 1996). The tendency of an individual to respond to a particular situation is based on the reinforcers or punishers available in the context, and his or her needs and internal goals related to those consequences. That is, a reinforcer will only serve to increase a response if the individual wants the reinforcer; a punisher will only decrease a response if the individual wants to avoid being punished (Skinner, 1968). Essentially, an individual's decision to participate or engage in any activity is based on the anticipated outcomes of his/her performance (Skinner, 1987c).

At the core of the behavioral view of motivation are the biological needs of the individual. Primary reinforcers (e.g, food, water, sleep, and sex) and primary punishers (i.e., anything that induces pain) are fundamental motives for action. Secondary reinforcers and punishers develop over time based on associations made between antecedent cues, behaviors, and consequences. More sophisticated motivations such as group affiliation, preferences for career, hobbies, etc. are all developed based on associations made in earlier and simpler experiences and the degree to which the individual's biological needs were met. Skinner (1987c) characterizes the development of motivation for more complex activity as a kind of rule-governed behavior. Pleasant or aversive consequences are associated with specific behaviors. Skinner considers rules, advice, etc. to be critical elements of any culture because "they enable the individual to profit from the experience of those who have experienced common contingencies and described this in useful ways" (p. 181). This position is not unlike current principles identified in what is referred to as the "social constructivist" perspective (e.g., Tharp & Gallimore, 1988; Vygotsky, 1978).

1.5 THE BEHAVIORAL ROOTS OF INSTRUCTIONAL TECHNOLOGY

1.5.1 Methodological Behaviorism

Stimulus–response behaviorism, that is, behaviorism which emphasizes the antecedent as the *cause* of the behavior, is generally referred to as methodological behaviorism (see e.g., Day, 1983; Skinner, 1974). As such, it is in line with much of experimental psychology; antecedents are the independent variables and the behaviors are the dependent variables. This transformational paradigm (Vargas, 1993) differs dramatically from the radical behaviorism of Skinner (e.g., 1945, 1974) which emphasizes the role of reinforcement of behaviors in the presence of certain antecedents, in other words, the selectionist position. Most of the earlier work in instructional technology followed the methodological behaviorist tradition. In fact, as we have said earlier, from a radical behaviorist position cognitive psychology is an extension of methodological behaviorism (Skinner, 1974). Although we have recast and reinterpreted where possible, the differences, particularly in the film and television research, are apparent. Nevertheless, the research is part of the research record in instructional technology and is therefore necessary, and moreover, useful from an S-R perspective.

One of the distinctive aspects of the methodological behavioral approach is the demand for "experimental" data (manipulation) to justify any interpretation of behavior as causal. Natural observation, personal experience and judgment fall short of the rules of evidence to support any psychological explanation (Kendler, 1971). This formula means that a learner must make the "correct response when the appropriate stimulus occurs" and when the necessary conditions are present.

> Usually there is no great problem in providing the appropriate stimulus, for audiovisual techniques have tremendous advantages over other educational procedures in their ability to present to the learner the stimuli in the most effective manner possible. (Kendler, 1971, p. 36)

A problem arises as to when to develop techniques (in which appropriate responses to specific stimuli can be practiced and reinforced). The developer of an instructional medium must know exactly what response is desired from the students, otherwise it is impossible to design and evaluate instruction. Once the response is specified, the problem becomes getting the student to make this appropriate response. This response must be practiced and the learner must be reinforced to make the correct response to this stimulus (Skinner, 1953b). Under the S-R paradigm, much of the research on the instructional media was based upon the medium itself (i.e., the specific technology). The medium became the independent variable and media comparison studies became the norm until the middle 1970s (Smith & Smith, 1966). In terms of the methodological behavior model, much of the media (programmed instruction, film, television, etc.) functioned primarily upon the stimulus component. From this position, Carpenter (1962) reasoned that any medium (e.g., film, television) "imprints" some of its own characteristics on the message itself. Therefore, the content and medium have more impact than the medium itself. The "way" the stimulus material (again film, television, etc.) interacts with the learner instigates motivated responses. Carpenter (1962) developed several hypotheses based upon his interpretations of the research on media and learning and include the following possibilities:

1. The most effective learning will take place when there is similarity between the stimulus material (presented via a medium) and the criterion or learned performance.
2. Repetition of stimulus materials and the learning response is a major condition for most kinds of learning.
3. Stimulus materials which are accurate, correct, and subject to validation can increase the opportunity for learning to take place.
4. An important condition is the relationship between a behavior and its consequences. Learning will occur when the behavior is "reinforced" (Skinner, 1968). This reinforcement, by definition, should be immediately after the response.
5. Carefully sequenced combinations of knowledge and skills presented in logical and limited steps will be the most effective for most types of learning.

6. ". . . established principles of learning derived from studies where the learning situation involved from direct instruction by teachers are equally applicable in the use of instructional materials" (Carpenter, 1962, p. 305).

Practical aspects of these theoretical suggestions go back to the mid-1920s with the development by Pressey of a self-scoring testing device. Pressey (1926, 1932) discussed the extension of this testing device into a self-instruction machine. Versions of these devices later (after World War II) evolved into several, reasonably sophisticated, teaching machines for the U.S. Air Force which were variations of an automatic self-checking technique. They included a punched card, a chemically treated card, a punch board, and the Drum Tutor. The Drum Tutor used informational material with multiple choice questions, but could not advance to the next question until the correct answer was chosen. All devices essentially allowed students to get immediate information concerning accuracy of response.

1.6 EARLY RESEARCH

1.6.1 Teaching Machines

Peterson (1931) conducted early research on Pressey's self-scoring testing devices. His experimental groups were given the chemically treated scoring cards used for self checking while studying a reading assignment. The control group had no knowledge of their results. Peterson found the experimental groups had significantly higher scores than the group without knowledge of results. Little (1934), also using Pressey's automatic scoring device, had the experimental group as a test-machine group, the second group using his testing teaching machine as a drill-machine and the third group as a control group in a paired controlled experiment. Both experimental groups scored significantly higher mean scores than the control group. The drill- and practice-machine group scored higher than the test-machine group. After World War II additional experiments using Pressey's devices were conducted. Angell and Troyer (1948) and Jones and Sawyer (1949) found that giving immediate feedback significantly enhanced learning in both citizenship and chemistry courses. Briggs (1947) and Jensen (1949) found that self-instruction by "superior" students using Pressey's punch boards enabled them to accelerate their course work. Pressey (1950) also reported on the efficacy of immediate feedback in English, Russian vocabulary, and psychology courses. Students given feedback via the punch boards received higher scores than those students who were not given immediate feedback. Stephens (1960), using Pressey's Drum Tutor, found students using the device scored better than students who did not. This was true even though the students using the Drum Tutor lacked overall academic ability. Stephens "confirmed Pressey's findings that errors were eliminated more rapidly with meaningful material and found that students learned more efficiently when they could correct errors immediately" (Smith & Smith, 1966, p. 249). Severin (1960) compared the scores of students given the correct answers with no overt responses in a practice test with those of students using the punch board practice test and found no significant differences. Apparently pointing out correct answers was enough and an overt response was not required. Pressey (1950) concluded that the use of his punch board created a single method of testing, scoring, informing students of their errors, and finding the correct solution all in one step (called telescoping). This telescoping procedure, in fact, allowed test taking to become a form of systematically directed self instruction. His investigations indicated that when self-instructional tests were used at the college level, gains were substantial and helped improve understanding. However, Pressey (1960) indicated his devices may not have been sufficient to stand by themselves, but were useful adjuncts to other teaching techniques.

Additional studies on similar self-instruction devices were conducted for military training research. Many of these studies used the automatic knowledge of accuracy devices such as The Tab Item and the Trainer-Tester (Smith & Smith, 1966). Cantor and Brown (1956) and Glaser, Damrin, and Gardner (1954) all found that scores for a troubleshooting task were higher for individuals using these devices than those using a mock-up for training. Dowell (1955) confirmed this, but also found that even higher scores were obtained when learners used the Trainer-Tester *and* the actual equipment. Briggs (1958) further developed a device called the Subject–Matter trainer which could be programmed into five teaching and testing modes. Briggs (1958) and Irion and Briggs (1957) found that prompting a student to give the correct response was more effective than just confirming correct responses.

Smith and Smith (1966) point out that while Pressey's devices were being developed and researched, they actually only attracted attention in somewhat limited circles. Popularity and attention were not generated until Skinner (1953a, 1953b, 1954) used these types of machines. "The fact that teaching machines were developed in more than one content would not be particularly significant were it not true that the two sources represent different approaches to educational design . . . " (Smith & Smith, 1966, p. 245). Skinner developed his machines to test and develop his operant conditioning principles developed from animal research. Skinner's ideas attracted attention, and as a result, the teaching machine and programmed instruction movement become a primary research emphasis during the 1960s. In fact, from 1960 to 1970, research on teaching machines and programming was the dominant type of media research in terms of numbers in the prestigious journal, *Audio-Visual Communication Review (AVCR)* (Torkelson, 1977). From 1960 to 1969, *AVCR* had a special section dedicated to teaching machines and programming concepts. Despite the fact of favorable research results from Pressey and his associates and the work done by the military, the technique was not popularized until Skinner (1954) recast self-instruction and self-testing. Skinner believed that any response could be reinforced. A desirable but seldom or never-elicited behavior could be taught by reinforcing a response which was easier to elicit but at some "distance" from the desired behavior. By reinforcing "successive" approximations, behavior will eventually approximate the desired pattern (Homme, 1957). Obviously, this paradigm, called shaping, required a great deal of supervision. Skinner believed that, in schools, reinforcement may happen hours, days, etc. after the desired behavior or behaviors and the effects would be greatly reduced. In addition, he felt that it was difficult to individually reinforce a response of an individual student in a large group. He also believed that school used negative reinforcers—to punish, not necessarily as reinforcement (Skinner, 1954). To solve these problems, Skinner also turned to the teaching machine concept. Skinner's (1958) machines in many respects were similar to Pressey's earlier teaching–testing devices. Both employed immediate knowledge of results immediately after the response. The students were kept active by their participation and both types of devices could be used in a self-instruction manner with students moving at their own rate. Differences in the types of responses in Pressey's and Skinner's machines should be noted. Skinner required students to "overtly" compose responses (e.g., writing words, terms, etc.). Pressey presented potential answers in a multiple choice format, requiring students to "select" the correct answer. In addition, Skinner (1958) believed that answers could not be easy, but that steps would need to be small in order for there to be no chance for "wrong" responses. Skinner was uncomfortable with multiple choice responses found in Pressey's devices because of the chance for mistakes (Homme, 1957; Porter, 1957; Skinner & Holland, 1960).

1.6.2 Films

The role and importance of military research during World War II and immediately afterward cannot be underestimated either in terms of amount or results. Research studies on learning, training materials, and instruments took on a vital role when it became necessary to train millions of individuals in skills useful for military purposes. People had to be selected and trained for complex and complicated machine systems (i.e., radio detection, submarine control, communication, etc.). As a result, most of the focus of the research by the military during and after the war was on the devices for training, assessment, and troubleshooting complex equipment and instruments. Much of the film research noted earlier stressed the stimulus, response, and reinforcement characteristics of the audiovisual device. "These [research studies] bear particularly on questions on the role of active response, size of demonstration and practice steps in procedural learning, and the use of prompts or response cues" (Lumsdaine & Glaser, 1960, p. 257). The major research programs during World War II were conducted on the use of films by the U.S. Army. These studies were conducted to study achievement of specific learning outcomes and the feasibility of utilizing film for psychological testings (Gibson, 1947; Hoban, 1946). After World War II, two major film research projects were sponsored by the United States Army and Navy at the Pennsylvania State University from 1947 to 1955 (Carpenter & Greenhill, 1955, 1958). A companion program on film research was sponsored by the United States Air Force from 1950 to 1957. The project at the Pennsylvania State University—the Instructional Film Research Program under the direction of C. R. Carpenter—was probably the "most extensive single program of experimentation dealing with instructional films ever conducted" (Saettler, 1968, p. 332). In 1954, this film research project was reorganized to include instructional films and instructional television because of the similarities of the two media. The Air Force Film Research Program (1950–1957) was conducted under the leadership of A. A. Lumsdaine (1961). The Air Force study involved the manipulation of techniques for "eliciting and guiding overt responses during a course of instruction" (Saettler, 1968, p. 335). Both the Army and Air Force studies developed research that had major implications for the use and design of audiovisual materials (e.g., film). Although these studies developed a large body of knowledge, little use of the results was actually implemented in the production of instructional materials developed by the military. Kanner (1960) suggested that the reason for the lack of use of the results of these studies was because they created resentment among film makers, and much of the research was completed in isolation.

Much of the research on television was generated after 1950 and was conducted by the military because of television's potential for mass instruction. Some of the research replicated or tested concepts (variables) used in the earlier film research, but the bulk of the research compared television instruction to "conventional" instruction, and most results showed no significant differences between the two forms. Most of the studies were applied rather than using a theoretical framework (i.e., behavior principles) (Kumata, 1961).

However, Gropper (1965a, 1965b), Gropper and Lumsdaine (1961a), and others used the television medium to test behavioral principles developed from the studies on programmed instruction. Klaus (1965) states that programming techniques tended to be either stimulus centered on response centered. Stimulus-centered techniques stressed meaning, structure, and organization of stimulus materials, while response-centered techniques dealt with the design of materials that ensure adequate response practice. For example, Gropper (1965a, 1966) adopted and extended concepts developed in programmed instruction (particularly the response centered model) to televised presentations. These studies dealt primarily with "techniques for bringing specific responses under the control of specific visual stimuli and . . . the use of visual stimuli processing such control within the framework of an instructional design" (Gropper, 1966, p. 41). Gropper, Lumsdaine, and Shipman (1961) and Gropper and Lumsdaine (1961a, 1961b, 1961c, 1961d) reported the value of pretesting and revising televised instruction and requiring students to make active responses. Gropper (1967) suggested that in television presentations it is desirable to identify which behavioral principles and techniques underlying programmed instruction are appropriate to television. Gropper and Lumsdaine (1961a–d) reported that merely requiring students to actively respond to nonprogrammed stimulus materials (i.e., segments which are not well delineated or sequenced in systematic ways) did not lead to more effective learning (an early attempt at formative evaluation). However, Gropper (1967) reported that the success of using programmed instructional techniques with television depends upon the effective design of the stimulus materials as well as the design of the appropriate response practice.

Gropper (1963, 1965a, 1966, 1967) emphasized the importance of using visual materials to help students acquire, retain, and transfer responses based on the ability of such materials to cue and reinforce specified responses, and serve as examples.

He further suggests that students should make explicit (active) responses to visual materials (i.e., television) for effective learning. Later, Gropper (1968) concluded that, in programmed televised materials, actual practice is superior to recognition practice in most cases and that the longer the delay in measuring retention, the more the active response was beneficial. The behavioral features that were original with programmed instruction and later used with television and film were attempts to minimize and later correct the defects in the effectiveness of instruction on the basis of what was known about the learning process (Klaus, 1965). Student responses were used in many studies as the basis for revisions of instructional design and content (e.g., Gropper, 1963, 1966). In-depth reviews of the audiovisual research carried on by the military and civilian researchers are contained in the classic summaries of this primarily behaviorist approach of Carpenter and Greenhill (1955, 1958), Chu and Schramm (1968), Cook (1960), Hoban (1960), Hoban and Van Ormer (1950), May and Lumsdaine (1958), and Schramm (1962).

The following is a sample of some of the research results on the behavioral tenets of stimulus, response, and reinforcement gleaned from the World War II research and soon after based upon the study of audiovisual devices (particularly film).

1.6.2.1 Research on Stimuli. Attempts to improve learning by manipulating the stimulus condition can be divided into several categories. One category, that of the use of introductory materials to introduce content in film or audiovisual research, has shown mixed results (Cook, 1960). Film studies by Weiss and Fine (1955), Wittich and Folkes (1946), and Wulff, Sheffield, and Kraeling (1954) reported that introductory materials presented prior to the showing of a film increased learning. But, Jaspen (1948), Lathrop (1949), Norford (1949), and Peterman and Bouscaren (1954) found inconclusive or negative results by using introductory materials. Another category of stimuli, those that direct attention, uses the behavioral principle that learning is assisted by the association of the responses to stimuli (Cook, 1960). Film studies by Gibson (1947), Kimble and Wulff (1953), Lumsdaine and Sulzer (1951), McGuire (1953a), Roshal (1949), and Ryan and Hochberg (1954) found that a version of the film which incorporated cues to guide the audience into making the correct responses produced increased learning. As might be expected, extraneous stimuli not focusing on relevant cues were not effective (Jaspen, 1950; Neu, 1950; Weiss, 1954). However, Miller and Levine (1952) and Miller, Levine, and Steinberger (1952a) reported the use of subtitles to associate content to be ineffective. Cook (1960) reported that many studies were conducted on the use of color where it would provide an essential cue to understanding with mixed results and concluded it was impossible to say color facilitated learning results (i.e., Long, 1946; May & Lumsdaine, 1958). Note that the use of color in instruction is still a highly debated research issue.

1.6.2.2 Research on Response. Cook (1960) stated the general belief that, unless the learner makes some form of response that is relevant to the learning task, no learning will occur. Responses (practice) in audiovisual presentations may range from overt oral, written, or motor responses to an implicit response (not overt). Cook, in an extensive review of practice in audiovisual presentations, reported the effectiveness of students calling out answers to questions in an audiovisual presentation to be effective (i.e., Kanner & Sulzer, 1955; Kendler, Cook, & Kendler, 1953; Kendler, Kendler, & Cook, 1954; McGuire, 1954). Most studies that utilized overt written responses with training film and television were also found to be effective (i.e., Michael, 1951; Michael & Maccoby, 1954; Yale Motion Picture Research Project, 1947).

A variety of film studies on implicit practice found this type of practice to be effective (some as effective as overt practice) (i.e., Kanner & Sulzer, 1955; Kendler et al., 1954; McGuire, 1954; Michael, 1951; Miller & Klier, 1953a, 1953b). Cook (1960) notes that the above studies all reported that the effect of actual practice is "specific to the items practiced" (p. 98) and there appeared to be no carryover to other items. The role of feedback in film studies has also been positively supported (Gibson, 1947; Michael, 1951; Michael & Maccoby, 1954).

The use of practice, given the above results, appears to be an effective component of using audiovisual (film and television) materials. A series of studies were conducted to determine the amount of practice needed. Cook (1960) concludes that students will profit from a larger number of repetitions (practice). Film studies that used a larger number of examples or required viewing the film more than once found students faring better than those with fewer examples or viewing opportunities (Brenner, Walter, & Kurtz, 1949; Kendler et al., 1953; Kimble & Wulff, 1954; Sulzer & Lumsdaine, 1952). A number of studies were conducted which tested when practice should occur. Was it better to practice concepts as a whole (massed) at the end of a film presentation or practice it immediately after it was demonstrated (distributed) during the film? Most studies reported results that there was no difference in the time spacing of practice (e.g., McGuire, 1953b; Miller & Klier, 1953a, 1953b, 1954; Miller et al., 1952a, 1952b). Miller and Levine (1952), however, found results in favor of a massed practice at the end of the treatment period.

1.6.3 Programmed Instruction

Closely akin, and developed from, Skinner's (1958) teaching machine concepts were the teaching texts or programmed books. These programmed books essentially had the same characteristics as the teaching machines; logical presentations of content, requirement of overt responses, and presentation of immediate knowledge of correctness (a correct answer would equal positive reinforcement (Porter, 1958; Smith & Smith, 1966). These programmed books were immediately popular for obvious reasons, they were easier to produce, portable, and did not require a complex, burdensome, and costly device (i.e., a machine). As noted earlier, during the decade of the 60s, research on programmed instruction, as the use of these types of books and machines became known, was immense (Campeau, 1974). Literally thousands of research studies were conducted. (See, for example, Campeau, 1974; Glaser, 1965a; Lumsdaine & Glaser, 1960; Smith & Smith, 1966, among others, for extensive summaries of research in this area.) The term programming is taken here to mean what Skinner called "the construction of carefully arranged sequences of contingencies leading to the terminal performances which are the object of education" (Skinner, 1953a, p. 169).

1.6.3.1 Linear Programming. Linear programming involves a series of learning frames presented in a set sequence. As in most of the educational research of the time, research on linear programmed instruction dealt with devices and/or machines and not on process nor the learner. Most of the studies, therefore, generally compared programmed instruction to "conventional" or "traditional" instructional methods (see e.g., *Teaching Machines and Programmed Instruction*, Glaser, 1965a). These types of studies were, of course, difficult to generalize from and often resulted in conflicting results (Holland, 1965). "The restrictions on interpretation of such a comparison arises from the lack of specificity of the instruction with which the instrument in questions is paired" (Lumsdaine, 1962, p. 251). Like other research of the time, many of the comparative studies had problems in design, poor criterion measures, scores prone to a ceiling effect, and ineffective and poor experimental procedures (Holland, 1965). Holland (1961), Lumsdaine (1965), and Rothkopf (1962) all suggested other ways of evaluating the success of programmed instruction. Glaser (1962a) indicated that most programmed instruction was difficult to construct, time consuming, and had few rules or procedures. Many comparative studies and reviews of comparative studies found no significance in the results of programmed instruction (e.g., Alexander, 1970; Barnes, 1970; Frase, 1970; Giese & Stockdale, 1966; McKeachie, 1967; Unwin, 1966; Wilds & Zachert, 1966). However, Daniel and Murdoch (1968), Hamilton and Heinkel (1967), and Marsh and Pierce-Jones (1968), all reported positive and statistically significant findings in favor of programmed instruction. The examples noted above were based upon gross comparisons. A large segment of the research on programmed instruction was devoted to "isolating or manipulating program or learner characteristics" (Campeau, 1974, p. 17). Specific areas of research on these characteristics included studies on repetition and dropout (for example, Rothkopf, 1960; Skinner & Holland, 1960). Skinner and Holland suggested that various kinds of cueing techniques could be employed which would reduce the possibility of error but generally will cause the presentation to become linear in nature (Skinner, 1961; Smith, 1959). Karis, Kent, and Gilbert (1970) found that overt responding such as writing a name in a (linear) programmed sequence was significantly better than for subjects who learned under covert response conditions. However, Valverde and Morgan (1970) concluded that eliminating redundancy in linear programs significantly increased achievement. Carr (1959) stated that merely confirming the correctness of a student's response as in a linear program is not enough. The learner must otherwise be motivated to perform (Smith & Smith, 1966). However, Coulson and Silberman (1960) and Evans, Glaser, and Homme (1962) found significant differences in favor of small (redundant) step programs over programs which had redundant and transitional materials removed. In the traditional linear program, after a learner has written his response (overt), the answer is confirmed by the presentation of the correct answer. Research on the confirmation (feedback) of results has shown conflicting results. Studies, for example, by Holland (1960), Hough and Revsin (1963), McDonald and Allen (1962), and Moore and Smith (1961, 1962) found no difference in mean scores due the added feedback. However, Kaess and Zeaman (1960), Meyer (1960), and Suppes and Ginsburg (1962) reported in their research, positive advantages for feedback on posttest scores. Homme and Glaser (1960) reported that when correct answers were omitted from linear programs, the learner felt it made no difference. Resnick (1963) felt that linear programs failed to make allowance for individual differences of the learners, and she was concerned about the "voice of authority" and the "right or wrong" nature of the material to be taught. Smith and Smith (1966) believed that a "linear program is deliberately limiting the media of communication, the experiences of the student and thus the range of understanding that he achieves" (p. 293).

Holland (1965) summarized his extensive review of literature on general principles of programming and generally found that a contingent relationship between the answer and the content is important. A low error rate of responses received support, as did the idea that examples are necessary for comprehension. For long programs, overt responses are necessary. Results are equivocal concerning multiple choice versus overt responses; however, many erroneous alternatives (e.g., multiple choice foils) may interfere with later learning. Many of the studies, however, concerning the effects of the linear presentation of content introduced the "pall effect" (boredom) due to the many small steps and the fact that the learner was always correct (Beck, 1959; Galanter, 1959; Rigney & Fry, 1961).

1.6.3.2 Intrinsic (Branching) Programming. Crowder (1961) used an approach similar to that developed by Pressey (1963) which suggested that a learner be exposed to a "substantial" and organized unit of instruction (e.g., a book chapter) and following this presentation a series of multiple choice questions would be asked "to enhance the clarity and stability of cognitive structure by correcting misconceptions and deferring the instruction of new matter until there had been such clarification and education" (Pressey, 1963, p. 3). Crowder (1959, 1960) and his associates were not as concerned about error rate or the limited step-by-step process of linear programs. Crowder tried to reproduce, in a self-instructional program, the function of a private tutor; to present new information to the learner and have the learner use this information (to answer questions); then taking "appropriate" action based upon learner's responses, such as going on to new information or going back and reviewing the older information if responses were incorrect. Crowder's intrinsic programming was designed to meet problems concerning complex problem solving but was not necessarily based upon a learning theory (Klaus, 1965). Crowder (1962) "assumes that the basic learning takes place during the exposure to the new material. The multiple choice question is asked to find out whether the student has learned; it is not necessarily regarded as playing an active part in the primary learning process" (p. 3). Crowder (1961), however, felt that the intrinsic (also known as branching) programs were essentially "naturalistic" and keep students working at the "maximum practical" rate.

Several studies have compared, and found no difference between, the type of constructed responses (overt vs. the multiple choice response in verbal programs) (Evans, Homme, & Glaser, 1962; Hough, 1962; Roe, Massey, Weltman, & Leeds, 1960; Williams, 1963). Holland (1965) felt that these studies showed, however, "the nature of the learning task determines the preferred response form. When the criterion performance includes a precise response . . . constructed responses seems to be the better form; whereas if mere recognition is desired the response form in the program is probably unimportant" (p. 104).

Although the advantages for the intrinsic (branching) program appear to be self-evident for learners with extreme individual differences, most studies, however, have found no advantages for the intrinsic programs over branching programs, but generally found time saving for students who used branching format (Beane, 1962; Campbell, 1961; Glaser, Reynolds, & Harakas, 1962; Roe, Massey, Weltman, & Leeds, 1962; Silberman, Melaragno, Coulson, & Estavan, 1961).

1.6.4 Instructional Design

Behaviorism is prominent in the roots of the systems approach to the design of instruction. Many of the tenets, terminology, and concepts can be traced to behavioral theories. Edward Thorndike in the early 1900s, for instance, had an interest in learning theory and testing. This interest greatly influenced the concept of instructional planning and the empirical approaches to the design of instruction. World War II researchers on training and training materials based much of their work on instructional principles derived from research on human behavior and theories of instruction and learning (Reiser, 1987). Heinich (1970) believed that concepts from the development of programmed learning influenced the development of the instructional design concept.

> By analyzing and breaking down content into specific behavioral objectives, devising the necessary steps to achieve the objectives, setting up procedures to try out and revise the steps, and by validating the program against attainment of the objectives, programmed instruction succeeded in creating a small but effective self-instructional system—a technology of instruction. (Heinich, 1970, p. 123)

Task analysis, behavioral objectives, and criterion-referenced testing were brought together by Gagné (1962) and Silvern (1964). These individuals were among the first to use terms such as systems development and instructional systems to describe a connected and systematic framework for the instructional design principles currently used (Reiser, 1987).

Instructional design is generally considered to be a systematic process that uses tenets of learning theories to plan and present instruction or instructional sequences. The obvious purpose of instructional design is to promote learning. As early as 1900, Dewey called for a "linking science" which connected learning theory and instruction (Dewey, 1900). As the adoption of analytic and systematic techniques influenced programmed instruction and other "programmed" presentation modes, early instructional design also used learning principles from behavioral psychology. For example, discriminations, generalizations, associations, etc. were used to analyze content and job tasks. Teaching and training concepts such as shaping and fading were early attempts to match conditions and treatments, and all had behavioral roots (Gropper & Ross, 1987). Many of the current instructional design models use major components of methodological behaviorism such as specification of objectives (behavioral), concentration on behavioral changes in students, and the emphasis on the stimulus (environment) (Gilbert, 1962; Reigeluth, 1983). In fact, some believe that it is this association between the stimulus and the student response that characterizes the influence of behavioral theory on instructional design (Smith & Ragan, 1993). Many of the proponents of behavioral theory, as a base for instructional design, feel that there is an "inevitable conclusion that the quality of an educational system must be defined primarily in terms of change in student behaviors" (Tosti & Ball, 1969, p. 6). Instruction, thus, must be evaluated by its ability to change the behavior of the individual student. The influence of the behavioral theory on instructional design can be traced from writings by Dewey, Thorndike and, of course, B. F. Skinner.

In addition, during World War II, military trainers (and psychologists) stated learning outcomes in terms of "performance" and found the need to identify specific "tasks" for a specific job (Gropper, 1983). Based on training in the military during World War II, a commitment to achieve practice and reinforcement became major components to the behaviorist developed instructional design model (as well as other nonbehavioristic models). Gropper indicates that an instructional design model should identify a unit of behavior to be analyzed, the conditions that can produce a change, and the resulting nature of that change. Again, for Gropper the unit of analysis, unfortunately, is the stimulus–response association. When the *appropriate* response is made and referenced after a (repeated) presentation of the stimulus, the response comes under the control of that stimulus.

> Whatever the nature of the stimulus, the response or the reinforcement, establishing stable stimulus control depends on the same two learning conditions: practice of an appropriate response in the presence of a stimulus that is to control it and delivery of reinforcement following its practice. (Gropper, 1983, p. 106)

Gropper stated that this need for control over the response by the stimulus contained several components; practice (to develop stimulus construction) and suitability for teaching the skills.

Gagné, Briggs, and Wager (1988) have identified several learning concepts that apply centrally to the behaviorial instructional design process. Among these are contiguity, repetition, and reinforcement in one form or another. Likewise, Gustafson and Tillman (1991) identify several major principles that underline instructional design. One, goals and objectives of the instruction need to be identified and stated; two, all instructional outcomes need to be measurable and meet standards of reliability and validity. Thirdly, the instructional design concept centers on changes in behavior of the student (the learner).

Corey (1971) identified a model that would include the above components. These components include:

1. *Determination of objectives*—This includes a description of behaviors to be expected as a result of the instruction and a description of the stimulus to which these behaviors are considered to be appropriate responses.
2. *Analysis of instructional objectives*—This includes analyzing "behaviors under the learner's control" prior to the instruction sequence, behaviors that are to result from the instruction.
3. *Identifying the characteristics of the students*—This would be the behavior that is already under the control of the learner prior to the instructional sequence.
4. *Evidence of the achievement of instruction*—This would include tests or other measures which would demonstrate whether or not the behaviors which the instruction "was designed to bring under his control actually were brought under his control" (p. 13).
5. *Constructing the instructional environment*—This involves developing an environment that will assist the student to perform the desired behaviors as response to the designed stimuli or situation.
6. *Continuing instruction (feedback)*—This involves reviewing if additional or revised instruction is needed to maintain the stimulus control over the learner's behavior.

Glaser (1965b) also described similar behavioral tenets of an instructional design system. He has identified the following tasks to teach subject matter knowledge. First, the behavior desired must be analyzed and standards of performance specified. The stimulus and desired response will determine what and how it is to be taught. Secondly, the characteristics of the students are identified prior to instruction. Thirdly, the student must be guided from one state of development to another using predetermined procedures and materials. Lastly, a provision for assessing the competence of the learner in relation to the predetermined performance criteria (objectives) must be developed.

Cook (1994) recently addressed the area of instructional effectiveness as it pertains to behavioral approaches to instruction. He notes that a number of behavioral instructional packages incorporate common underlying principles that promote teaching and student learning and examined a number of these packages concerning their inclusion of 12 components he considers critical to instructional effectiveness.

1. Task analysis and the specification of the objectives of the instructional system
2. Identification of the entering skills of the target population, and a placement system that addresses the individual differences amongst members of the target population
3. An instructional strategy in which a sequence of instructional steps reflects principles of behavior in the formation of discriminations, the construction of chains, the elaboration of these two elements into concepts and procedures, and their integration and formalization by means of appropriate verbal behavior such as rule statements
4. Requests and opportunities for active student responding at intervals appropriate to the sequence of steps in #3
5. Supplementary prompts to support early responding
6. The transfer of the new skill to the full context of application (the facing of supporting prompts as the full context takes control; this may include the fading of verbal behavior which has acted as part of the supporting prompt system)
7. Provision of feedback on responses and cumulative progress reports, both at intervals appropriate to the learner and the stage in the program
8. The detection and correction of errors
9. A mastery requirement for each well-defined unit including the attainment of fluency in the unit skills as measured by the speed at which they can be performed
10. Internalization of behavior that no longer needs to be performed publicly; this may include verbal behavior that remains needed but not in overt form
11. Sufficient self-pacing to accommodate individual differences in rates of achieving mastery
12. Modification of instructional programs on the basis of objective data on effectiveness with samples of individuals from the target population

1.6.4.1 Task Analysis and Behavioral Objectives. As we have discussed, one of the major components derived from behavioral theory in instructional design is the use of behavioral objectives. The methods associated with task analysis and programmed instruction stress the importance of the "identification and specification of observable behaviors to be performed by the learner" (Reiser, 1987, p. 23). Objectives have been used by educators as far back as the early 1900s (e.g., Bobbitt, 1918). Although these objectives may have identified content that might be tested (Tyler, 1949), usually they did not specify exact behaviors learners were to demonstrate based upon exposure to the content (Reiser, 1987). Popularization and refinement of stating objectives in measurable or observable terms within an instructional design approach was credited by Kibler, Cegala, Miles, and Barker (1974), and Reiser (1987) to the efforts of Bloom, Engelhart, Furst, Hill, and Krathwohl (1956), Mager (1962), Gagné (1965), Glaser (1962b), Popham and Baker (1970), and Tyler (1934). Kibler and colleagues point out that there are many rational bases for using behavioral objectives, some of which are not learning-theory based, such as teacher accountability. They list, however, some of the tenets that are based upon behavioral learning theories. These include (1) assisting in evaluating learners' performance, (2) designing and arranging sequences of instruction, and (3) communicating requirements and expectations and providing and communicating levels of performance prior to instruction. In the Kibler et al. comprehensive review of the empirical bases for using objectives, only about 50 studies that dealt with the effectiveness of objectives were found. These researchers reported that results were inconsistent and provided little conclusive evidence of the effect of behavioral objectives on learning. They classified the research on objectives into four categories. These were:

1. *Effects of student knowledge of behavioral objectives on learning.* Of 33 studies, only 11 reported student possession

of objectives improved learning significantly (e.g., Doty, 1968; Lawrence, 1970; Olsen, 1972; Webb, 1971). The rest of the studies found no differences between student possession of objectives or not (e.g., Baker, 1969; Brown, 1970; Patton, 1972; Weinberg, 1970; Zimmerman, 1972).

2. *Effects of specific versus general objectives on learning.* Only two studies (Dalis, 1970; Janeczko, 1971) found that students receiving specific objectives performed higher than those receiving general objectives. Other studies (e.g., Lovett, 1971; Stedman, 1970; Weinberg, 1970) found no significant differences between the forms of objectives.
3. *Effects on student learning of teacher possession and use of objectives.* Five of eight studies reviewed found no significant differences of teacher possession of objectives and those without (e.g., Baker, 1969; Crooks, 1971; Kalish, 1972). Three studies reported significant positive effects of teacher possession (McNeil, 1967; Piatt, 1969; Wittrock, 1962).
4. *Effects of student possession of behavioral objectives on efficiency (time).* Two of seven studies (Allen & McDonald, 1963; Mager & McCann, 1961) found use of objectives reducing student time on learning. The rest found no differences concerning efficiency (e.g., Loh, 1972; Smith, 1970).

Kibler and colleagues (1974) found less than half of the research studies reviewed supported the use of objectives. However, they felt that many of the studies had methodological problems. These were: lack of standardization of operationalizing behavior objectives, unfamiliarity with the use of objectives by students, and few researchers provided teachers with training in the use of objectives. Although they reported no conclusive results in their reviews of behavioral objectives, Kibler and colleagues felt that there were still logical reasons (noted earlier) for their continued use.

1.7 CURRENT DESIGN AND DELIVERY MODELS

Five behavioral design/delivery models are worth examining in some detail: Personalized System of Instruction (PSI), Bloom's (1971) Learning for Mastery, Precision Teaching, Direct Instruction, and distance learning/tutoring systems. Each of the first four models has been in use for some 30 years and each share some distinctively behavioral methodologies such as incremental units of instruction, student-oriented objectives, active student responding, frequent testing, and rapid feedback. The fifth model, distance learning/tutoring systems, has grown rapidly in recent years due to the extensive development and availability of computers and computer technology. Increasingly, distance learning systems are recognizing the importance of and adopting these behavioral methodologies due to their history of success.

Additional class features of behavioral methodologies are inherent in these models. First and foremost, each model places the responsibility for success on the instruction/teacher as opposed to the learner. This places a high premium on validation and revision of materials. In fact, in all behavior models, instruction is always plastic; always, in a sense, in a formative stage. Another major feature is a task or logical analysis which is used to establish behavioral objectives and serve as the basis for precise assessment of learner entry behavior. A third essential feature is emphasis on meeting the needs of the individual learner. In most of these models, instruction is self-paced and designed based on learner's mastery of the curriculum. When the instruction is not formally individualized (i.e., direct instruction), independent practice is an essential phase of the process to ensure individual mastery. Other common characteristics of these models include the use of small groups, carefully planned or even scripted lessons, high learner response requirements coupled with equally high feedback, and, of course, data collection related to accuracy and speed. Each of these programs is consistent with all, or nearly all, of the principles from Cook (1994) listed previously.

1.7.1 Personalized System of Instruction

Following a discussion of B. F. Skinner's Principles of the Analysis of Behavior (Holland & Skinner, 1961), Fred Keller and his associates concluded that "traditional teaching methods were sadly out of date" (Keller & Sherman, 1974, p. 7). Keller suggested that if education was to improve, instructional design systems would need to be developed to improve and update methods of providing instructional information. Keller searched for a way in which instruction could follow a methodical pattern. The pattern should use previous success to reinforce the student to progress in a systematic manner toward a specified outcome. Keller and his associates developed such a system, called Personalized System of Instruction (PSI) or the Keller Plan. PSI can be described as an interlocking system of instruction, consisting of sequential, progressive tasks designed as highly individualized learning activities. In this design, students determine their own rate and amount of learning, as they progress through a series of instructional tasks (Liu, 2001). In his seminal paper "Goodbye, Teacher . . . '' (Keller, 1968), Keller describes the five components of PSI, which are:

1. The go-at-your-own pace feature (self-pacing)
2. The unit-perfection requirement for advancement (mastery)
3. The use of lectures and demonstrations as vehicles of motivation
4. The related stress upon the written word in teacher–student communication
5. The use of proctors for feedback

The first feature of PSI allows a student to move at his/her own pace through a course at a self-determined speed. The unit-perfection requirement means that before the student can move to the next unit of instruction, he/she must complete perfectly the assessment given on the previous unit. Motivation for a PSI course is provided by a positive reward structure. Students who have attained a certain level of mastery, as indicated by the number of completed units, are rewarded through special lectures and demonstrations. Communication, in classic PSI systems, relies primarily on written communication between student and teacher. However, the proctor–student relationship relies on both written and verbal communication, which provides valuable feedback for students (Keller, 1968).

A PSI class is highly structured. All information is packaged into small, individual units. The student is given a unit, reads the information, proceeds through the exercises, and then reports to a proctor for the unit assessment. After completing the quiz, the student returns the answers to the proctor for immediate grading and feedback. If the score is unsatisfactory (as designated by the instructor), the student is asked to reexamine the material and return for another assessment. After completion of a certain number of units, the student's reward is permission to attend a lecture, demonstration, or field trip, which is instructor-led. At the end of the course, a final exam is given. The student moves at his/her own pace, but is expected to complete all units by the end of the semester (Keller, 1968). PSI was widely used in the 1970s in higher education courses (Sherman, 1992). After the initial use of PSI became widespread, many studies focused on the effect that these individual features have on the success of a PSI course (Liu, 2001).

1.7.1.1 The Effect of Pacing. The emphasis on self-pacing has led some PSI practitioners to cite procrastination as a problem in their classes (Gallup, 1971; Hess, 1971; Sherman, 1972). In the first semester of a PSI course on physics at the State University College, Plattsburgh, Szydlik (1974) reported that 20/28 students received incompletes for failure to complete the requisite number of units. In an effort to combat procrastination, researchers started including some instructor deadlines with penalties (pacing contingencies) if the students failed to meet the deadlines.

Semb, Conyers, Spencer, and Sanchez-Sosa (1975) conducted a study that examined the effects of four pacing contingencies on course withdrawals, the timing of student quiz-taking throughout the course, performance on exams, and student evaluations. They divided an introductory child development class into four groups and exposed each group to a different pacing contingency. Each group was shown a "minimal rate" line that was a suggested rate of progress. The first group received no benefit or punishment for staying at or above the minimum rate. The second group (penalty) was punished if they were found below the minimum rate line, losing 25 points for every day they were below the rate line. The third group (reward 1) benefited from staying above the minimum rate line by earning extra points. The fourth group (reward 2) also benefited from staying above the minimum rate line by potentially gaining an extra 20 points overall. All students were told that if they did not complete the course by the end of the semester, they would receive an Incomplete and could finish the course later with no penalty. Students could withdraw from the course at any point in the semester with a 'withdraw passing' grade (Semb et al., 1975).

The results of the course withdrawal and incomplete study showed that students with no contingency pacing had the highest percentage (23.8%) of withdrawals and incompletes. The second group (penalty) had the lowest percentage of withdrawals and incompletes (2.4%). With regard to procrastination, students in Groups 2–4 maintained a relatively steady rate of progress while Group 1 showed the traditional pattern of procrastination. No significant differences were found between any groups on performance on exams or quizzes. Nor were there any significant differences between groups regarding student evaluations (Semb et al., 1975).

In an almost exact replication of this study, Reiser (1984) again examined whether reward, penalty, or self-pacing was most effective in a PSI course. No difference between groups was found regarding performance on the final exam, and there was no difference in student attitude. However, students in the penalty group had significantly reduced procrastination. The reward group did not show a significant reduction in procrastination, which contradicts the findings by Semb et al. (1975).

1.7.1.2 The Effect of Unit Perfection for Advancement. Another requirement for a PSI course is that the content be broken into small, discrete, units. These units are then mastered individually by the student. Several studies have examined the effect the number of units has on student performance in a PSI course. Born (1975) took an introductory psychology class taught using PSI and divided it into three sections. One section had to master 18 quizzes over the 18 units. The second section had to master one quiz every two units. The third section was required to master one quiz every three units. Therefore, each section had the same 18 units, but the number of quizzes differed. Surprisingly, there was no difference between the three groups of students in terms of performance on quizzes. However, Section one students spent a much shorter time on the quizzes than did Section three students (Born, 1975).

Another study examined the effect of breaking up course material into units of 30, 60, and 90 pages (O'Neill, Johnston, Walters, & Rashed, 1975). Students performed worst in the first attempt on each unit quiz when they had learned the material from the large course unit. Students exposed to a large unit also delayed starting the next unit. Also, more attempts at mastering the quizzes had to be made when students were exposed to a large unit. Despite these effects, the size of the unit did not affect the final attempt to meet the mastery criterion. They also observed student behavior and stated that the larger the unit the more time the student spent studying. Students with a large unit spent more time reading the unit, but less time summarizing, taking notes, and other interactive behaviors (O'Neill et al., 1975).

Student self-pacing has been cited as one aspect of PSI that students enjoy (Fernald, Chiseri, Lawson, Scroggs, & Riddell, 1975). Therefore, it could be motivational. A study conducted by Reiser (1984) found that students who proceeded through a class at their own pace, under a penalty system or under a reward system, did not differ significantly in their attitude toward the PSI course. The attitude of all three groups toward the course was generally favorable (at least 63% responded positively). These results agreed with his conclusions of a previous study (Reiser, 1980). Another motivating aspect of PSI is the removal of the external locus of control. Because of the demand for perfection on each smaller unit, the grade distribution of PSI courses is skewed toward the higher grades, taking away the external locus of control provided by an emphasis on grades (Born & Herbert, 1974; Keller, 1968; Ryan, 1974).

1.7.1.3 The Emphasis on Written and Verbal Communication. Written communication is the primary means of communication for PSI instruction and feedback. Naturally, this would be an unacceptable teaching strategy for students whose writing skills are below average. If proctors are used, students may express their knowledge verbally, which may assist in improving the widespread application of PSI. The stress on the written word has not been widely examined as a research question. However, there have been studies conducted on the study guides in PSI courses (Liu, 2001).

1.7.1.4 The Role of the Proctor. The proctor plays a pivotal role in a PSI course. Keller (1968) states that proctors provide reinforcement via immediate feedback and, by this, increase the chances of continued success in the future. The proctors explain the errors in the students' thought processes that led them to an incorrect answer and provide positive reinforcement when the students perform well. Farmer, Lachter, Blaustein, and Cole (1972) analyzed the role of proctoring by quantifying the amount of proctoring that different sections of the course received. They randomly assigned a class of 124 undergraduates into five groups (0, 25, 50, 75, and 100%) that received different amounts of proctoring on 20 units of instruction. One group received 0% proctoring, that is, no interaction with a proctor at all. The group that received 25% proctoring interacted with the proctor on five units, and so on. They concluded that the amount of proctoring did not affect performance significantly, as there was no significant difference between students who received the different amounts of proctoring. However, no proctoring led to significantly lower scores when compared with the different groups of students who had received proctoring (Farmer et al., 1972).

In a crossover experiment by Fernald and colleagues (1975), three instructional variables, student pacing, the perfection requirement, and proctoring, were manipulated to see their effects on performance and student preferences. Eight different combinations of the three instructional variables were formed. For example, one combination might have a student interact a lot with a proctor, a perfection requirement, and use student pacing. In this design, eight groups of students were exposed to two combinations of 'opposite' instruction variables sequentially over a semester: a student receiving much contact, perfection, and a teacher-paced section would next experience a little contact, no perfection, and student-paced section (Fernald et al., 1975).

The results of this experiment showed that students performed best when exposed to a high amount of contact with a proctor and when it was self-paced. These results were unexpected because traditional PSI classes require mastery. The variable that had the greatest effect was the pacing variable. Student pacing always enhanced performance on exams and quizzes. The mastery requirement was found to have no effect. However, the authors acknowledge that the perfection requirement might not have been challenging enough. They state that a mastery requirement may only have an effect on performance when the task is difficult enough to cause variation among students (Fernald et al., 1975).

1.7.1.5 Performance Results Using the PSI Method. A meta-analysis by Kulik, Kulik, and Cohen (1979) examined 75 comparative studies about PSI usage. Their conclusion was that PSI produces superior student achievement, less variation in achievement, and higher student ratings in numerous college courses. Another meta-analysis on PSI conducted more recently by Kulik, Kulik, and Bangert-Downs (1990) found similar results. In this analysis, mastery learning programs (PSI and Bloom's Learning for Mastery) were shown to have positive effects on students' achievement and that low aptitude students benefited most from PSI. They also concluded that mastery learning programs had long-term effects even though the percentage of students that completed PSI college classes is smaller than the percentage that completed conventional classes (Kulik et al., 1990).

1.7.2 Bloom's Learning for Mastery

1.7.2.1 Theoretical Basis for Bloom's Learning for Mastery. At about the same time that Keller was formulating and implementing his theories, Bloom was formulating his theory of Learning for Mastery (LFM). Bloom derived his model for mastery learning from John Carroll's work and grounded it in behavioral elements such as incremental units of instruction, frequent testing, active student responding, rapid feedback, and self-pacing. Carroll (as cited in Bloom, 1971) proposed that if learners is normally distributed with respect to aptitude and they receive the same instruction on a topic, then the achievement of the learners is normally distributed as well. However, if the aptitude is normally distributed, but each learner receives optimal instruction with ample time to learn, then achievement will not be normally distributed. Instead, the majority of learners will achieve mastery and the correlation between aptitude and achievement will approach zero (Bloom, 1971).

Five criteria for a mastery learning strategy come from Carroll's work (Bloom, 1971). These are:

1. Aptitude for particular kinds of learning
2. Quality of instruction
3. Ability to understand instruction
4. Perseverance
5. Time allowed for learning

The first criterion concerns aptitude. Prior to the concept of mastery learning, it was assumed that aptitude tests were good predictors of student achievement. Therefore, it was believed that only some students would be capable of high achievement. Mastery learning proposes that aptitude is the amount of time required by the learner to gain mastery (Bloom, 1971). Therefore, Bloom asserts that 95% of all learners can gain mastery of a subject if given enough time and appropriate instruction (Bloom, 1971).

Secondly, the quality of instruction should focus on the individual. Bloom (1971) states that not all learners will learn best from the same method of instruction and that the focus of instruction should be on each learner. Because understanding instruction is imperative to learning, Bloom advocates a variety of teaching techniques so that any learner can learn. These include the use of tutors, audiovisual methods, games, and small-group study sessions. Similarly, perseverance is required to master a task. Perseverance can be increased by increasing learning success, and the amount of perseverance required can be reduced by good instruction. Finally, the time allowed for learning should be flexible so that all learners can master the material. However, Bloom also acknowledges the constraints of school schedules and states that an effective mastery learning program will alter the amount of time needed to master instruction.

1.7.2.2 Components of Learning for Mastery. Block built upon Bloom's theory and refined it into two sections: preconditions and operating procedures. In the precondition section, teachers defined instructional objectives, defined the level of mastery, and prepared a final exam over the objectives. The content was then divided into smaller teaching units with a formative evaluation to be conducted after instruction. Then the alternative instructional materials (correctives) were developed that were keyed to each item on the unit test. This provided alternative ways of learning for learners should they have failed to master the material after the first attempt (Block & Anderson, 1975). During the operating phase, the teacher taught the material to the learners and then administered the evaluation. The learners who failed to master the material were responsible for mastering it before the next unit of instruction was provided. After all instruction was given, the final exam was administered (Block & Anderson, 1975).

In the most recent meta-analysis of Bloom's LFM, Kulik et al., (1990) concluded that LFM raised examination scores by an average of 0.59 standard deviations. LFM was most effective when all five criteria were met. When the subject matter was social sciences, the positive effect that LFM had was larger. Secondly, LFM had a more marked effect on locally developed tests, rather than national standardized tests. However, LFM learners performed similarly to non-LFM learners on standardized tests. When the teacher controlled the pace, learners in an LFM class performed better. Fourthly, LFM had a greater effect when the level of mastery was set very high (i.e., 100% correct) on unit quizzes. Finally, when LFM learners and non-LFM learners receive similar amounts of feedback, the LFM effect decreases. That is, less feedback for non-LFM learners caused a greater effect of LFM (Kulik et al., 1990). Additional conclusions that Kulik et al. draw are: that low aptitude learners can gain more than high aptitude learners, the benefits of LFM are enduring, not short-term, and finally, learners are more satisfied with their instruction and have a more positive attitude (Liu, 2001).

Learning tasks are designed as highly individualized activities within the class. Students work at their own rate, largely independent from the teacher. The teacher usually provides motivation only through the use of cues and feedback on course content as students progress through the unit (Metzler, Eddleman, Treanor, & Cregger, 1989).

Research on PSI in the classroom setting has been extensive (e.g., Callahan & Smith, 1990; Cregger & Metzler, 1992; Hymel, 1987; McLaughlin, 1991; Zencias, Davis, & Cuvo, 1990). Often it has been limited to comparisons with designs using conventional strategies. It has been demonstrated that PSI and similar mastery-based instruction can be extremely effective in producing significant gains in student achievement (e.g., Block, Efthim, & Burns, 1989; Guskey, 1985). Often PSI research focuses on comparisons to Bloom's Learning for Mastery (LFM) (Bloom, 1971). LFM and PSI share a few characteristics among these are the use of mastery learning, increased teacher freedom, and increased student skill practice time. In both systems, each task must be performed to a criterion determined prior to the beginning of the course (Metzler et al., 1989).

Reiser (1987) points to the similarity between LFM and PSI in the method of student progression through the separate systems. Upon completion of each task, the student is given the choice of advancing or continuing work within that unit. However, whereas PSI allows the student to continue working on the same task until mastery is reached, LFM recommends a "looping-back" to a previous lesson and proceeding forward from that point (Bloom, 1971).

This similarity between systems extends to PSI's use of providing information to the learners in small chunks, or tasks, with frequent assessment of these smaller learning units (Siedentop, Mand, & Taggert, 1986). These chunks are built on simple tasks, to allow the learner success before advancing to more complex tasks. As in PSI, success LFM is developed through many opportunities for practice trials with the instructor providing cues and feedback on the task being attempted. These cues and feedback are offered in the place of lectures and demonstrations. Though Bloom's LFM approach shares many similarities with Keller's design, PSI actually extends the concept of mastery to include attention to the individual student as he or she progresses through the sequence of learning tasks (Reiser, 1987).

Several studies have compared self-pacing approaches with reinforcement (positive or negative rewards) in a PSI setting. Keller (1968) has suggested that it was not necessary to provide any pacing contingencies. Others have used procedures that reward students for maintaining a pace (Cheney & Powers, 1971; Lloyd, 1971), or penalized students for failing to do so (Miller, Weaver, & Semb, 1954; Reiser & Sullivan, 1977). Calhoun (1976), Morris, Surber, and Bijou (1978), Reiser (1980), and Semb et al. (1975) report that learning was not affected by the type of pacing procedure. However, Allen, Giat, and Cheney (1974), Sheppard and MacDermot (1970), and Sutterer and Holloway (1975) reported that the "prompt completion of work is positively related to achievement in PSI courses" (Reiser, 1980, p. 200).

Reiser (1984), however, reported that student rates of progress is improved and learning is unhindered when pacing with penalties are used (e.g., Reiser & Sullivan, 1977; Robin & Graham, 1974). In most cases (except Fernald et al., 1975; Robin & Graham, 1974), student attitudes are as positive with a penalty approach as with a regular self-paced approach without penalty (e.g., Calhoun, 1976; Reiser, 1980; Reiser & Sullivan, 1977).

1.7.3 Precision Teaching

Precision teaching is the creation of O. R. Lindsley (Potts, Eshleman, & Cooper, 1993; Vargas, 1977). Building upon his own early research with humans (e.g., Lindsley, 1956, 1964, 1972, 1991a, 1991b; Lindsley & Skinner, 1954) proposed that rate, rather than percent correct, might prove more sensitive to monitoring classroom learning. Rather than creating programs based on laboratory findings, Lindsley proposed that the measurement framework that had become the hallmark of the laboratories of Skinner and his associates be moved into the classroom. His goal was to put science in the hands of teachers and students (Binder & Watkins, 1990). In Lindsley's (1990a) words, his associates and he (e.g., Caldwell, 1966; Fink, 1968; Holzschuh & Dobbs, 1966) "did not set out to discover basic laws of behavior. Rather, we merely intended to monitor standard self-recorded performance frequencies in the classroom" (p. 7). The most conspicuous result of these efforts was the Standard Behavior Chart or Standard Celeration Chart, a six–cycle, semi-logarithmic graph for charting behavior frequency against days.

> By creating linear representations of learning (trends in performance) on the semi-logarithmic chart, and quantifying them as multiplicative factors per week (e.g., correct responses × 2.0 per week minus errors divided by 1.5 per week), Lindsley defined the first simple measure of learning in the literature: *Celeration* (either a multiplicative acceleration of behavior frequency or a dividing deceleration of behavior frequency per celeration period, e.g., per week). (Binder & Watkins, 1990, p. 78)

Evidence suggests that celeration, a direct measure of learning, is not racially biased (Koening & Kunzelmann, 1981).

In addition to the behavioral methodologies mentioned in the introduction to this section, precision teachers use behavioral techniques including applied behavior analysis, individualized programming and behavior change strategies, and student self-monitoring. They distinguish between operational or descriptive definitions of event, which require merely observation, versus functional definitions that require manipulative (and continued observation). Precision teachers apply the "dead man's test" to descriptions of behavior, that is, "If a dead man can do it, then don't try to teach it" (Binder & Watkins, 1990), to rule out objectives such as "sits quietly in chair" or "keeps eyes on paper." The emphasis of Precision Teaching has been on teaching teachers *and students* to count behaviors with an emphasis on counting and analyzing both correct and incorrect response (i.e., learning opportunities) (White, 1986). As Vargas (1977) points out, "This problem-solving approach to changing behavior is not only a method, it is also an outlook, a willingness to judge by what works, not by what we like to do or what we already believe" (p. 47).

The Precision Teaching movement has resulted in some practical findings of potential use to education technologists. For example, Precision Teachers have consistently found that placement of students in more difficult tasks (which produce higher error rates), results in faster learning rates (see e.g., Johnson, 1971; Johnson & Layng, 1994; Neufeld & Lindsley, 1980). Precision Teachers have also made fluency, accuracy plus speed of performance, a goal at each level of a student's progress. Fluency (or automaticity or "second nature" responding) has been shown to improve retention, transfer of training, and "endurance" or resistance to extinction (Binder, 1987, 1988, 1993; Binder, Haughton, & VanEyk, 1990). (It is important to note that fluency is not merely a new word for "overlearning," or continuing to practice past mastery. Fluency involves speed, and indeed speed may be more important than accuracy, at least initially). Consistent with the findings that more difficult placement produces bigger gains are the findings of Bower and Orgel (1981) and Lindsley (1990b) that encouraging students to respond at very high rates from the beginning, even when error rates are high, can significantly increase learning rates.

Large-scale implementations of Precision Teaching have found that improvements of two or more grade levels per year are common (e.g., West, Young, & Spooner, 1990). "The improvements themselves are dramatic; but when cost/benefit is considered, they are staggering, since the time allocated to precision teach was relatively small and the materials used were quite inexpensive" (Binder & Watkins, 1989, p. 82–83).

1.7.4 Direct Instruction

Direct Instruction (DI) is a design and implementation model based on the work of Siegfried Engelmann (Bereiter & Engelmann, 1966; Engelmann, 1980), and refined through 30+ years of research and development. DI uses behavioral tenets such as scripted lessons, active student responding, rapid feedback, self-pacing, student-oriented objectives, and mastery learning as part of the methodology. According to Binder and Watkins (1990), over 50 commercially available programs are based on the DI model. The major premise of the DI is that learners are expected to derive learning that is consistent with the presentation offered by the teacher. Learners acquire information through choice–response discriminations, production–response discriminations, and sentence–relationship discriminations. The key activity for the teacher is to identify the type of discrimination required in a particular task, and design a specific sequence to teach the discrimination so that only the teacher's interpretation of the information is possible. Engelmann and Carnine (1982, 1991) state that this procedure requires three analyses: the analysis of behavior, the analysis of communications, and the analysis of knowledge systems.

The analysis of behavior is concerned with how the environment influences learner behavior (e.g., how to prompt and reinforce responses, how to correct errors, etc.). The analysis of communications seeks principles for the logical design of effective teaching sequences. These principles relate to the ordering of examples to maximize generalization (but minimize overgeneralization). The analysis of knowledge systems is concerned with the logical organization or classification of knowledge such that similar skills and concepts can be taught the same way and instruction can proceed from simple to complex. Direct instruction uses scripted presentations not only to support quality control, but because most teachers lack training in design and are, therefore, not likely to select and sequence examples effectively without such explicit instructions (Binder & Watkins, 1990). Engelmann (1980) asserts that these scripted lessons release the teacher to focus on:

1. The presentation and communication of the information to children
2. Students' prerequisite skills and capabilities to have success with the target task
3. Potential problems identified in the task analysis
4. How children learn by pinpointing learner successes and strategies for success
5. Attainment
6. Learning how to construct well-designed tasks

Direct instruction also relies on small groups (10–15), unison responding (to get high response rates from *all* students) to fixed signals from the teacher, rapid pacing, and correction procedures for dealing with student errors (Carnine, Grossen, & Silbert, 1994). Generalization and transfer are the result of six "shifts" that Becker and Carnine (1981) say should occur in any well-designed program: overtized to covertized problem solving, simplified contexts to complex contexts, prompts to no prompts, massed to distributed practice, immediate to delayed feedback, and teacher's roles to learner's role as a source of information.

Watkins (1988), in the Project Follow Through evaluation, compared over 20 different instructional models and found Direct Instruction to be the most effective of all programs on measures of basic skills achievement, cognitive skills, and self concept. Direct Instruction has been shown to produce higher reading and math scores (Becker & Gersten, 1982), more high-school diplomas, less grade retention, and fewer dropouts than students who did not participate (Englemann, Becker, Carnine, & Gersten, 1988; Gersten, 1982; Gersten & Carnine, 1983; Gersten & Keating, 1983). Gersten, Keating, and Becker (1988) found modest differences in Direct Instruction students three, six, and nine years after the program with one notable exception: reading. Reading showed a strong long-term benefit consistently across all sites. Currently, the DI approach is a central pedagogy in Slavin's Success for All program, a very popular program that provides remedial support for early readers in danger of failure.

1.7.5 The Morningside Model

The Morningside Model of Generative Instruction and Fluency (Johnson & Layng, 1992) puts together aspects of Precision Teaching, Direct Instruction, Personalized System of Instruction with the Instructional Content Analysis of Markle and Tiemann (Markle & Droege, 1980; Tiemann & Markle, 1990), and the guidelines provided by Markle (1964, 1969, 1991). The Morningside Model has apparently been used, to date, exclusively by the Morningside Academy in Seattle (since 1980) and Malcolm X College, Chicago (since 1991). The program offers instruction for both children and adults in virtually all skill areas. Johnson and Layng report impressive comparative gains "across the board." From the perspective of the Instructional Technologist, probably the most impressive statistic was the average gain per hour of instruction; across all studies summarized, Johnson and Layng found that 20 to 25 hours of instruction per skill using Morningside Model instruction resulted in nearly a two-grade level "payoff" as compared to the U.S. government standard of one grade level per 100 hours. Sixty hours of inservice was given to new teachers, and design time/costs were not estimated, but the potential cost benefit of the model seem obvious.

1.7.6 Distance Education and Tutoring Systems

The explosive rise in the use of distance education to meet the needs of individual learners has revitalized the infusion of behavioral principles into the design and implementation of computer-based instructional programs (McIssac & Gunawardena, 1996). Because integration with the academic environment and student support systems are important factors in student success (Cookson, 1989; Keegan, 1986), many distance education programs try to provide student tutors to their distance learners. Moore and Kearsley (1996) stated that the primary reason for having tutors in distance education is to individualize instruction. They also asserted that having tutors available in a distance education course generally improves student completion rates and achievement.

The functions of tutors in distance education are diverse and encompassing, including: discussing course material, providing feedback in terms of progress and grades, assisting students in planning their work, motivating the students, keeping student records, and supervising projects. However, providing feedback is critical for a good learning experience (Moore & Kearsley, 1996). Race (1989) stated that the most important functions of the tutors are to provide objective feedback and grades and use good model answers. Holmberg (1977) stated that students profit from comments from human tutors provided within 7–10 days of assignment submission.

The Open University has historically used human tutors in many different roles, including counselor, grader, and consultant (Keegan, 1986). The Open University's student support system has included regional face-to-face tutorial sessions and a personal (usually local) tutor for grading purposes. Teaching at the Open University has been primarily through these tutor marked assignments. Summative and formative evaluation by the tutor has occurred though the postal system, the telephone, or face-to-face sessions. Despite the success of this system (>70% retention rate), recently the Open University has begun moving to the Internet for its student support services (Thomas, Carswell, Price, & Petre, 1998).

The Open University is using the Internet for registration, assignment handling, student–tutor interactions, and exams. The new electronic system for handling assignments addresses many limitations of the previous postal system such as, turn-around time for feedback and reduced reliance upon postal systems. The tutor still grades the assignments, but now the corrections are made in a word processing tool that makes it easier to read (Thomas et al., 1998).

The Open University is also using the Internet for tutor–tutee contact. Previously, tutors held face-to-face sessions where students could interact with each other and the tutor. However, the cost of maintaining facilities where these sessions could take place was expensive and the organization of tutor groups and schedules was complex. Additionally, one of the reasons students choose distance learning is the freedom from traditional school hours. The face-to-face sessions were difficult for some students to attend. The Open University has moved to computer conferencing, which integrates with administrative components to reduce the complexity of managing tutors (Thomas et al., 1998).

Rowe and Gregor (1999) developed a computer-based learning system that uses the World Wide Web for delivery. Integral to the system are question–answer tutorials and programming tutorials. The question and answer tutorials were multiple choice and graded instantly after submission. The programming tutorials required the students to provide short answers to questions. These questions were checked by the computer and if necessary, sent to a human tutor for clarification. After using this format for two years at the University of Dundee, the computer-based learning system was evaluated by a small student focus group with representatives from all the levels of academic achievement in the class. Students were asked about the interface, motivation, and learning value.

Students enjoyed the use of the web browser for distance learning, especially when colors were used in the instruction (Rowe & Gregor, 1999). With regards to the tutorials, students wanted to see the question, their answer, and the correct answer on the screen at the same time, along with feedback as to why the answer was wrong or right. Some students wanted to e-mail answers to a human tutor because of the natural language barrier. Since the computer-based learning system was used as a supplement to lecture and lab sessions, students found it to be motivating. They found that the system fulfilled gaps in knowledge and could learn in their own time and at their own pace. They especially liked the interactivity of the web. Learners did not feel that they learned more with the computer-based system, but that their learning was reinforced.

An interesting and novel approach to distance learning in online groups has been proposed by Whatley, Staniford, Beer, and Scown (1999). They proposed using agent technology to develop individual "tutors" that monitor a student's participation in a group online project. An agent is self-contained, concurrently executing software that captures a particular state of knowledge and communicates with other agents. Each student would have an agent that would monitor that student's progress, measure it against a group plan, and intervene when necessary to insure that each student completes his/her part of the project. While this approach differs from a traditional tutor approach, it still retains some of the characteristics of a human tutor, those of monitoring progress and intervening when necessary (Whatley et al., 1999).

1.7.7 Computers as Tutors

Tutors have been used to improve learning since Socrates. However, there are limitations on the availability of tutors to distance learners. In 1977, Holmberg stated that some distance education programs use preproduced tutor comments and received favorable feedback from students on this method. However, advances in available technology have further developed the microcomputer as a possible tutor. Bennett (1999) asserts that using computers as tutors has multiple advantages, including self-pacing, the availability of help at any time in the instructional process, constant evaluation and assessment of the student, requisite mastery of fundamental material, and providing remediation. In addition, he states that computers as tutors will reduce prejudice, help the disadvantaged, support the more advanced students, and provide a higher level of interest with the use of multimedia components (Bennett, p.76–119). Consistent across this research on tutoring systems, the rapid feedback provided by computers is beneficial and enjoyable to the students (Holmberg, 1977).

Halff (1988, p. 79) identifies three roles of computers as tutors:

1. Exercising control over curriculum by selecting and sequencing the material
2. Responding to learners' questions about the subject
3. Determining when learners need help in developing a skill and what sort of help they need

Cohen, Kulik, and Kulik (1982) examined 65 school tutoring programs and showed that students receiving tutoring outperformed nontutored students on exams. Tutoring also affected student attitudes. Students who received tutoring developed a positive attitude toward the subject matter (Cohen et al., 1982). Since tutors have positive effects on learning, they are a desirable component to have in an instructional experience.

Thus, after over 25 years of research it is clear that behavioral design and delivery models "work." In fact, the large-scale implementations reviewed here were found to produce gains above two grade levels (e.g., Bloom, 1984; Guskey, 1985). Moreover, the models appear to be cost effective. Why then are they no longer fashionable? Perhaps because behaviorism has not been taught for several academic generations. Most people in design have never read original behavioral sources; nor had the professors who taught them. Behaviorism is often interpreted briefly and poorly. It has become a straw man to contrast more appealing, more current, learning notions.

1.8 CONCLUSION

This brings us to the final points of this piece. First, what do current notions such as situated cognition and social constructive add to radical behaviorism? How well does each account for the other? Behaviorism is rich enough to account for both, is historically older, and has the advantage of parsimony; it is the simplest explanation of the facts. We do not believe that advocates of either could come up with a study which discriminates between their position as opposed to behaviorism *except* through the use of mentalistic explanations. Skinner's work was criticized often for being too descriptive—for not offering explanation. Yet, it has been supplanted by a tradition that prides itself on qualitative, descriptive analysis. Do the structures and dualistic mentalisms add anything? We think not. Radical behaviorism provides a means to both describe events and ascribe causality.

Anderson (1985) once noted that the problem in cognitive theory (although we could substitute all current theories in psychology) was that of nonidentifiability; cognitive theories simply do not make different predictions that distinguish between them. Moreover, what passes as theory is a collection of mini-theories and hypotheses without a unifying system. Cognitive theory necessitates a view of evolution that includes a step beyond the rest of the natural world or perhaps even the purpose of evolution!

> We seem, thus, to have arrived at a concept of how the physical universe about us—all the life that inhabits the speck we occupy in this universe—has evolved over the eons of time by simple material processes, the sort of processes we examine experimentally, which we describe by equations, and call the "laws of nature." Except for one thing! Man is conscious of his existence. Man also possesses, so most of us believe, what he calls his free will. Did consciousness and free will too arise merely out of "natural" processes? The question is central to the contention between those who see nothing beyond a new materialism and those who see—Something. (Vanevar Bush, 1965, as cited in Skinner, 1974)

Skinner (1974) makes the point in his introduction to *About Behaviorism* that behaviorism is not the science of behaviorism; it is the philosophy of that science. As such, it provides the best vehicle for Educational Technologists to describe and converse about human learning and behavior. Moreover, its assumptions that the responsibility for teaching/instruction resides in the teacher or designer "makes sense" if we are to "sell our wares." In a sense, cognitive psychology and its offshoots are collapsing from the weight of the structures it postulates. Behaviorism "worked" even when it was often misunderstood and misapplied. Behaviorism is simple, elegant, and consistent. Behaviorism *is* a relevant and viable philosophy to provide a foundation and guidance for instructional technology. It has enormous potential in distance learning settings. Scholars and practitioners need to revisit the original sources of this literature to truly know its promise for student learning.

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