18. CONDITIONS-BASED MODELS FOR DESIGNING INSTRUCTION

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18.1 INTRODUCTION

One of the most influential and pervasive theories underlying instructional design are the propositions that: (a) There are identifiably different types of learning outcomes, and (b) the acquisition of these outcomes requires different internal and external conditions of learning.[1] In other words, this theory suggests that all learning is not qualitatively the same, that there are learning outcomes across contents, contexts, and learners that have significant and identifiable similarities in their cognitive demands on the learner. Further, each learning outcome category has significant and identifiable differences in its cognitive demands from the demands of other learning outcome categories. Finally, as this family of theories is instructional in nature, they propose that these distinctive cognitive processing demands can be supported by equally distinctive instructional methods, strategies, tactics, or conditions.

These propositions underlie what Wilson and Cole (1991) terms a "conditions-of-learning" paradigm of instructional design. Models of instructional design that follow a conditions-based theory are predicated upon the seminal principles of Robert Gagné (1966): (a) Learning can be classified into categories that require similar cognitive activities for learning (Gagné termed these "internal conditions of learning"); and, therefore, (b) within these categories of learning, similar instructional supports are needed to facilitate learning (Gagné termed these "external conditions of learning").

The influence of a conditions-based perspective can be found in the task analysis, strategy development, assessment, and evaluation procedures of conditions-based instructional design models. However, the point at which the conditions-based perspective has the greatest influence and most unique contribution is on the development of instructional strategies. According to conditions-based models, when designing instructional strategies, instructional designers must determine the goals of instruction, categorize these goals as to outcome category, and select strategies that have been suggested as being effective for this category of learning outcome (or devise strategies consistent with the cognitive processing demands of the learning task).

Examples of conditions-based models of design have been authored by Gagné (1985) and Gagné, Briggs, and Wager (1988), Merrill (1983), Reigeluth (1979), Merrill and Li (1990), and Smith and Ragan (1993). Other authors, though they may not posit a complete approach to instructional design or "model," have suggested conditions-based approaches to strategy design (e.g., Horn, 1976; Landa, 1983). Interestingly, several of these explications (Jonassen, Grabinger & Harris, 1991; West, Farmer & Wolf, 1991) present the instructional processes first and then suggest the learning outcomes for which these strategies might be appropriate.

The purpose of this chapter is to describe the evolution of the conditions-based perspective, exemplify and compare conditions-based models, and examine the assumptions of the conditions-based model both theoretically and empirically. These assumptions are:

1. Learning goals can be categorized as to learning outcome or knowledge type.
2. Learning outcomes can be represented in a predictable prerequisite relationship.
3. Acquisition of different outcome categories requires different internal processes (or, different internal processes lead to different cognitive outcomes).
4. Different internal processes are supported by identifiably different instructional processes (or, different instructional processes lead to different internal processes).

[1] We refer here to "conditions of learning" as described by Gagné (1985) as external conditions of learning, that is, those instructional supports that are designed to promote learning, rather than instructional conditions as described by Reigeluth and Merrill (1978), which are primarily learner and learning context variables.

18.2 EVOLUTION OF THE CONDITIONS-BASED THEORY

The first full statement of a conditions-based theory of instruction appears to have been by R. M. Gagné in the early 1960s.[2] However, there was a considerable amount of conjecture within this paradigm by a variety of researchers prior to Gagné. In addition, Gagné and others have developed a conditions-based theory along a variety of lines of thought until the present day. In this section, we will review work leading to the conditions model, discuss Gagné's early and evolving conceptions, and review various lines of research in the conditions-based tradition which have appeared subsequent to Gagné's first work (see also 1.6, 5.2).

18.2.1 Early Work Leading to Conditions-Based Thinking

Among the earliest writing that specifically addresses the need to beware of overgeneralization of knowledge about learning, Carr (1933) cautioned that conclusions that are valid for one category of learning may not be valid for others. The categories of which Carr spoke were not within a formally defined taxonomy or system, but rather they were reflected in the different experimental tasks, research procedures, and measures employed in different studies.

Interest in devising useful categories of learning persisted over the decade, and Melton wrote in the learning theory chapter in the 1941 *Encyclopedia of Educational Research* (Melton, 1941) of efforts to develop a psychologically based taxonomy of learning outcomes. During this same period, Tolman (1949) described six categories of learning, and Woodworth (1958) described five categories.

The behaviorist movement lent a rigor and precision to the study of learning that is perhaps difficult to appreciate today (see 1.4.4, 1.4.5, 2.2.2.3). When one looks at the work of some behaviorist learning researchers, one finds compelling (if not esoteric) evidence that there are different kinds of learning with different conditions for their attainment. Wickens (1962) described Spence's studies of animal learning involving both aversive conditioning and approach behaviors:

> Spence (1956) has used the same approach in differentiation of the instrumental avoidance situation of the type represented by the eyelid conditioning from an approach learning represented by an animal scurrying down a runway for its daily pellet. Spence is quite specific: The antecedent of *H* (the intervening variable leading to the running response) in the latter case is a function only of *n* and not of incentive magnitude; in the former, it—the intervening variable *H*—is a function of *n* and also of magnitude of the UCS. This conclusion leads him to describe the excitatory component of behavior, *E*, as being a function of two intervening variables, *H* and *D*, insofar as classical aversive conditioning is concerned, while the excitatory component of runway behavior requires, for him, three intervening variables, *H*, *D*, and *K* (Wickens, 1962, p. 81).

Another specification of differences in learning tasks is seen in Bloom's taxonomy (Bloom, Englehart, Furst, Hill & Krathwohl, 1956). This group's thinking about the need for a taxonomy of educational outcomes originated at an informal meeting of college examiners at the 1948 meeting of the American Psychological Association, at which "interest was expressed in a theoretical framework that could be used to facilitate communication among examiners" (Bloom et al., 1956, p. 4). The taxonomy arose not from a synthesis of research but in response to a collective need for standardization of terminology.

Applications of Bloom's taxonomy, however, have frequently assumed a stature similar to that of psychologically based approaches. For example, a study by Kunen, Cohen & Solman (1981) investigated the cumulative hierarchical assumption of Bloom's taxonomy. The study concluded that there is "moderately strong support for the assumption that the taxonomy represents a cumulative hierarchy of categories of cognitive operations" (p. 207). The tasks used in the study involved recall of knowledge, recall of applications, recall of words related to a synthesis task, and so forth ("the dependent variable was the number of critical words correctly free recalled," p. 207). As all of the tasks appear to involve recall, we have some doubt about the validity of conclusions supporting a hierarchy of cognitive operations. Furst's (1981) review of research on Bloom's taxonomy leveled a great deal of criticism of the taxonomy in terms of its lack of cumulative hierarchical structure. It seems clear that the taxonomy's uses have exceeded its original design and purpose.

18.2.2 Military and Industry Training Researchers

In the 1950s and 1960s (and continuing to the present), a substantial amount of research and development related to learning and instruction has been conducted by the military services and industry (see also 1.10). Edling and associates pointed out that this group of scientists in military and industrial settings was large for its work to be so unfamiliar to many educators. Indeed, in 1963 the Army's HumRRO employed 100 "training psychologists" of whom 65 were Ph.D.s, and the Air Force Training and Research Center at one time employed 168 psychologists of whom 100 held Ph.D.s (Edling et al., 1972, p. 94).

Among the contributions of these researchers were some "relatively sophisticated taxonomies of learner tasks," such as those developed by Cotterman (1959), Demaree (1961), Lumsdaine (1960), Miller (1962), Parker and Downs (1961),

[2] A full statement of Gagné's conditions model appears in Gagné, "Problem Solving," in A.W. Melton's 1964 edited work, *Categories of Learning*. The paper on which the chapter is based was delivered in a symposium convened by Melton in January 1962, for the purpose of exploring "the interrelationship of different categories of learning" (Melton, 1964, p. vii).

Stolurow (1963), and Willis (1961). Gagné's work, also perceived of evolving within this context, was seen to be "particularly powerful" (Edling, 1972, p. 95).

Of these taxonomies, Miller's treatment of learning types illuminates the idea of "task analysis" as it was viewed in the 1950s and early 1960s (Miller, 1953, 1954, 1956, 1962). Miller, employed by IBM, proposed that an "equipment task analysis" description "should include analysis of perceptual, short-term recall, long-term recall, decision-making and motor processes implied by the initial equipment task analysis" (Smode, 1962, p. 435). Miller reflected the mainstream approach by focusing on job tasks, although it is clear that consideration of cognitive processes greatly influenced much of his analysis scheme's structure and content.

Much of the progress in defining learning tasks made by the military and corporate researchers may be attributed to their employer's demands. Increasingly, technical training requirements in the military and in industry were placing high demands on the skills of training designers to develop instruction in problem solving, troubleshooting, and other expertise-related tasks. Bryan (1962) discussed the pertinence of troubleshooting studies to the topics of transfer, concept formation, problem solving, decision making, thinking, and learning. To perhaps exaggerate a bit, one can envision academic colleagues running rats in the laboratories, while their counterparts who were employed by the military and large corporations were struggling with issues of human learning and skilled performance. This pressure to describe complex learning (often felt by academics as well) forced behaviorally trained psychologists to consider cognitive issues long before the mainstream, and produced a unique blend of "neobehaviorism" with what we might call "precognitive" psychology. As we view Gagné's work and its evolution, this blend and transition will be clearly illustrated.

18.2.3 Academic Learning Psychologists

The thinking of academic psychologists about types of learning are well represented in a 1964 volume edited by A. W. Melton, *Categories of Human Learning*. In chapters by N. H. Anderson, E. J. Archer, G. E. Briggs, J. Deese, W. K. Estes, P. M. Fitts, R. M. Gagné, D. A. Grant, H. A. Kendler, T. S. Kendler, G. A. Kimble, A. W. Melton, L. Postman, B. J. Underwood, and D. D. Wickens, concerns and progress toward understanding varieties of human learning are discussed. Two of these contributions will be discussed here for the information they contain on state of the art and as illustrations of the categories defined within this period.

Underwood (1964) discussed possible approaches to a taxonomy of human learning, proposing how it would be possible "to express the relationships among research findings for all forms of human learning" (p. 48). Underwood noted that a single, grand unified theory did not yet exist in which a master set of statements and relationships could lead to deductions of findings in each of the various areas of interest in learning research. A second approach that Underwood suggested in the absence of a grand unified theory was to attempt to

> express the continuity for all human learning . . . in terms of phenomena produced by comparable operations. Thus, can the operations defining extinction in eyelid conditioning be duplicated in verbal learning, in motor learning, in concept formation, and so on, and, if so, do the same phenomena result from these operations? (p. 48).

Underwood (p. 48) noted that a difficulty in doing such cross-category research is that the differences among tasks make it physically impossible to manipulate them in comparable manners:

> For example, it would seem difficult to manipulate meaningfulness on a pursuit rotor in the same sense that this variable is manipulated in verbal learning. Or, what operations in problem solving are comparable to variations in intensity of the conditioned stimulus in classical conditioning?

Underwood later described a technique for determining the similarity of learning in different situations. That technique is illustrated in work by Richardson (1958) in which "A descriptive difference between concept formation and rote verbal learning can be stated in terms of the number of identical responses to be associated with similar stimuli" (p. 49). The number of responses to a stimulus associated with a concept-learning task was different from the number of responses to the same stimulus when it was part of a rote-learning task, reflecting a lack of "continuity" between the two types of tasks.

In a seminal chapter in *Categories of Human Learning*, Melton (1964) pointed out that neither the physical structures of the human organism nor its cognitive processes themselves (such as motivational, perceptual, and performance processes) provide guidance for a taxonomy of learning, as such structures would provide in classifying physical attributes. Of the need for a conditions-based approach, Melton (1964, p. 327) bemoans the lack of articulation between training design questions and knowledge about learning:

> When one is confronted with a decision to use massed or distributed practice, to insist on information feedback or not to insist on it, to arrange training so as to maximize or minimize requirements for contiguous stimulus differentiation, etc., and (one) discovers that the guidance received from experimental research and theory is different for rote learning, for skill learning, and for problem solving, taxonomic issues become critical and taxonomic ambiguities become frustrating, to say the least.

A strong element of formalism, in addition to the practical concerns noted in the quote above, seems to shape Melton's thinking, which is illustrative for the time in which he was writing. Melton wrote at length about a "taxonomy" of learning from the standpoint of taxonomies themselves and how they come about in science. A persistent theme is how the "primitive categories" will end up being used—to what extent they will be used and how they

can conceivably be modified. The primitive categories, reflected to a large extent by chapter topics in the book, are rather long-standing areas of research and theory interest in learning psychology: conditioning, rote learning, probability learning, skills learning, concept learning, and problem solving. Apparently, Melton expected that all of these topics should, as organized in some appropriate and meaningful way, be related to one another in a taxonomic, hierarchical structure. One may notice, coincidentally perhaps, that Gagné's first edition of *Conditions of Learning* included a set of learning types that were, unlike those found in more recent editions, in toto a taxonomic list, in which each category in the classification scheme was prerequisite to the others (with the exception of the first category, classical conditioning). In later versions of the types of learning, Gagné included many categories that he did not propose as being in hierarchical relationship (only the learning types within the intellectual skills category are proposed as hierarchical in more current versions.)

18.3 CONTRIBUTIONS OF R. M. GAGNÉ

As R. M. Gagné is generally identified as the primary originator of a conditions-based model of instructional design, an understanding of his evolution of thought becomes foundational to understanding the theory that extends beyond his contribution.

18.3.1 Precursors to Gagné's Conditions-Based Theory

In a review of factors that contribute to learning efficiency for a volume on programmed instruction sponsored by the Air Force Office of Scientific Research, Gagné and Bolles noted that "the learning tasks that have been most intensively studied by psychologists have been of an artificial "laboratory" variety; relatively little is known about learning in real life situations" (Gagné & Bolles, 1959, pp. 13–14). In 1962, as one who worked as a researcher in an academic setting, then as a researcher and research director in a military setting, and finally back in the academic setting, Gagné reflected on military training research in an article entitled "Military Training and Principles of Learning."

Training research in the 1950s (see 1.10) put Gagné in touch with a wide variety of instructional problems, representing a wide variety of learning tasks. Illustrative studies in the literature are Gagné (1954), "An Analysis of Two Problem Solving Activities," involving troubleshooting and interpretation of aerial photographs, and Gagné, Baker, and Wylie (1951), "Effects of an Interfering Task on the Learning of a Complex Motor Skill," involving manipulations of controls similar to aircraft controls. In a review of problem solving and thinking, Gagné pointed out the relevance of troubleshooting studies to issues in concept formation (Gagné, 1959). Wide and vigorous participation in research on learning and instruction in the military environment, along with his thorough and rigorous background as a learning psychologist, may have created the dissonance that motivated Gagné to develop the concepts of types of learning outcomes, learning hierarchies and events of instruction, and conditions of learning.

18.3.2 Development of Types of Learning

In his chapter on problem solving for Melton's *Categories of Human Learning,* Gagné (1964) presents a table entitled "A Suggested Ordering of the Types of Human Learning," in which he proposed the following six types of learning: response learning, chaining, verbal learning (paired associates), concept learning, principle learning, problem solving (p. 312). He did not cite a previous publication of his here, so this may be the first appearance of his types-of-learning scheme. This is not to say that he had not engaged in much previous thought and writing on important differences between forms of learning. However, the pulling together of types of learning to form a totally inclusive scheme containing mutually exclusive elements appears to have taken place around the time the "Categories of Learning" symposium was taking place, early in 1962.

Gagné's thinking on types of learning is illustrated by his discussion of problem solving as a form of learning. In the following, he points out how problem solving, as a form of learning, differs from other forms of learning:

> . . . the learning situation for problem solving never includes performances which could, by simple summation, constitute the criterion performance. In conditioning and trial-and-error learning, the performance finally exhibited (blinking an eye, or tracing a path) occurs as part of the learning situation. In verbal learning, the syllables or words to be learned are included in the learning situation. In concept learning, however, this is not always so, and there is consequently a resemblance to problem solving in this respect. Although mediation experiments may present a concept during learning which is later a part of the criterion performance, many concept learning experiments do not use this procedure. Instead they require the S to respond with a performance scored in a way which was not directly given in learning (the stating of an abstraction such as "round" or "long and rectangular"). Similarly, the "solution" of the problem is not presented within the learning situation for problem solving. Concept formation and problem solving are *nonreproductive* types of learning (Gagné, 1964, p. 311).

Perhaps the first full and complete statement of the types of learning conception appeared in the first edition of *The Conditions of Learning* (Gagné, 1965). In that work, Gagné began by reviewing learning theory and research, such as that by James, Dewey, Watson, Thorndike, Tolman, Ebbinghaus, Pavlov, and Köhler. To introduce the idea of types of learning, Gagné presents the notion of "learning prototypes": "Throughout the period of scientific investigation of learning there has been frequent recourse to certain typical experimental situations to serve as prototypes for

learning" (p.18). The differences in kinds of learning among these prototypes is seen in the inability to "reduce" one variety to another, although many attempts have been made" (p. 18). To clarify how these distinctive forms of learning have come to be lumped together as one form, Gagné (pp. 18–19) pointed out:

> These learning prototypes all have a similar history in this respect: each of them started to be a representative of a particular variety of learning situation. Thorndike wanted to study animal association. Pavlov was studying reflexes. Ebbinghaus studied the memorization of verbal lists. Köhler was studying the solving of problems by animals. By some peculiar semantic process, these examples became prototypes of learning, and thus were considered to represent the domain of learning as a whole, or at least in large part.

Gagné (1965) presented eight types of learning in the first edition, in a strict hierarchical relationship. All types but the first, signal learning (classical conditioning), have prerequisite relationships with one another. The eight types of learning, with corresponding researcher links, were:

1. Signal learning (Pavlov, 1927)
2. Stimulus-response learning (Thorndike, 1989; Skinner, 1938; Kimball, 1961)
3. Chaining (Skinner, 1938; Gilbert, 1962)
4. Verbal association (Underwood, 1964)
5. Multiple discrimination (Postman, 1961)
6. Concept learning (Kendler, 1964)
7. Principle learning (Gagné, 1964)
8. Problem solving (Katona, 1940; Maier, 1930)

Regarding the distinctions between these types, Gagné describes support for some of the distinctions (Gagné, 1965, p. 59). Table 18-1 summarizes that discussion.

Later editions of *Conditions of Learning* modified the list of types of learning considerably. Although the second edition (Gagné, 1970) reflected no change in the number or labeling of the eight types of learning, by the third edition (Gagné, 1977) information-processing theories were added to the treatment of learning prototypes, and a large section was added on information processing along with recasting the types of learning (see 5.4.1). The information-processing perspective, present in the third edition, was not part of the first or second edition, even though earlier work reflected a strong information-processing background (Gagné 1962c). Surprisingly, while Gagné's primary base was shifting from behavioral to cognitive in the third edition, task characteristics, rather than psychological processes, begin to guide the form and content of the types of learning. In Gagné's fourth edition (1985), a hierarchical, prerequisite relationship is limited to four subcategories of one major category, intellectual skills. The types of learning in the fourth edition are:

1. Intellectual skills
   - discriminations
   - concepts
   - rules
   - problem solving
2. Cognitive strategies
3. Verbal information
4. Motor skills
5. Attitudes

Gagné's descriptions of the categories of problem solving and cognitive strategies have continued to evolve in recent years. For example, in Gagné and Glaser (1987), "problem solving" was combined into one category along with cognitive strategies. Inspection of the text reveals that, in fact, domain-specific problem solving was meant here, along with strategies for learning and strategies for remembering (see pp. 66–67). The evaluation of Gagné's problem-solving category can also be noted in his fourth edition of *Conditions of Learning,* in which problem solving was moved out of the intellectual skills category as higher-order rules and appears to have become a category separate from both the rule-based learning of intellectual skills and the domain-general category of cognitive strategy.

Gagné and Merrill (1990) described an approach to the integration of multiple learning objectives for larger, longer-term efforts that are unified through "pursuit of a comprehensive purpose in which the learner is engaged, called an enterprise" (p. 23). A learning enterprise may be defined as "a purposive activity that may depend for its execution on some combination of verbal information, intellectual skills, and cognitive strategies, all related by their involvement in the common goal" (p. 25). The storage of enterprises is discussed in terms of mental models (Gentner & Stevens, 1983), schemata (Rummelhart & Norman, 1978), and work models (Bunderson, Gibbons, Olsen & Kearsley, 1981). Three kinds of enterprise schemata are described: denoting, manifesting, and discovering. Disappointingly, all of their examples are of individual learning, not of sets of them.

What do these categories of learning represent? Gagné described the types of learning outcomes as "learned dispositions," "capabilities," or "long-term memory states" (p. 245), qualities that reside within the learner. He further described two of these categories, verbal information and intellectual skills, as having distinctly different memory storage systems. Gagné and White (1978) provided an empirical basis for the "verbal information" knowledge to be stored as propositional networks. They further described rule using as stored in

TABLE 18-1. SUMMARY OF THE ETIOLOGY OF LEARNING TYPES

Type 1 distinct from type 2:	Thorndike, 1989 Skinner, 1938 Hull, 1934
Type 3 as a distinct form:	Skinner, 1938 Hull, 1943
Type 5 distinct from type 6:	Mowrer, 1960b Harlow, 1959

hierarchical skill structures, which they at that time called *intellectual skills.*

More recently, Gagné (1985) has described verbal information learning as stored as propositional networks or schemata. He describes rules, including defining rules or concepts, as stored as "If . . . then" productions. He does not suggest how problem-solving capabilities themselves are stored, although he implied that they are interconnections of schemata and productions. Nor does he explicitly conjecture regarding the storage mechanisms of attitudes, motor skills, or cognitive strategies.

As the concept of types of learning evolved from its neobehaviorist beginnings to a more cognitive orientation seen in the fourth edition of *Conditions of Learning,* the research basis for differences in conditions for their achievement appears to have been largely lost. Although the concept remains as intuitively valid as ever to many instructional technologists, direct support in the literature is shockingly absent. Kyllonen and Schute (1989) describe Gagné's types of learning as a "rational taxonomy," being developed via proposing "task categories in terms of characteristics that will foster or inhibit learned performance" (p. 120). The drawback to such an approach is that its basis does not lie in psychological processes and, therefore, such processes are unsystematically considered.

18.3.3 Development of the Learning Hierarchies Concept

A study by Gagné and Brown (1961) revealed thinking that led directly to Gagné's conceptions of learning hierarchies and types of learning. Here, in the context of programmed instruction, Gagné and Brown were concerned with the acquisition of meaningful "conceptual" learning, as compared with the rote memorization or association learning that characterized the work of Holland and Skinner:

> . . . from an examination of representative published examples of programs (e.g., Holland, 1959; Skinner, 1958), it is not immediately apparent that they are conveying "understanding" in the sense of capability for inducing transfer to new problem situations. They appear to be concerned primarily with the usages of words in a variety of stimulus contexts" (p. 174).

The phenomenon of transfer appears to have been central to Gagné and Brown's concerns, both of transfer from prerequisite learnings to higher-level outcomes (sometimes termed *vertical transfer*) and in terms of transfer from the learning situation to later application (sometimes termed *lateral transfer*). Although a great deal of attention is given to the study's programmed instruction format in the report, it is clear that the authors' interests were focused on a question of vertical transfer to problem solving (the particular learning task would now be considered relational rule use).

In Gagné and Brown (1961), the authors described a study with a programmed instruction lesson teaching concepts (see 2.3.4) related to number series: the terms *value* and *number.* After a common introduction to the fundamental concepts, the study employed three treatment methods to teach application of the concepts to finding the key to number series problems: (1) rule & example (R&E), (2) discovery (D), and (3) guided discovery (GD). The authors considered issues such as "size of step" and others of interest in programmed-instruction research of the day. However, they concluded that "some aspect of what has been learned . . . is of greater effect than how it has been learned" (p. 181). The difference in "what" as supplied by the three treatments was that the guided discovery method required use of previously learned concepts in a new context.

Although all three methods were effective in teaching learners to solve numerical series problems, the GD and D methods were superior to the R&E method, with the GD method being the most effective of all. The inferiority of the R&E method was attributed to the fact that it did not *require* learners to practice the application of concepts to a problem situation. In other conditions, learners could make the application but were believed to have, in general, not applied the concepts to the problem situation.

A postscript: It is ironic perhaps that in this early study, one that employed programmed instruction methods and reflects Gagné's thinking at that time very much as a neobehaviorist, the instructional strategies labeled "discovery" and "guided discovery" were found to provide superior instruction. It should be noted that the "discovery" method used was more structured than what many today might construct: A good amount of supplantive instruction on prerequisites preceded the "discovery" condition.

Gagné's first references to "learning hierarchies" appears in articles published in 1962: a report of a study, "Factors in Acquiring Knowledge of a Mathematical Task," and another study, "The Acquisition of Knowledge," which involved similar learning tasks. These reports were preceded by a study by Gagné and Paradise (1961) which formed a foundation for the latter studies. In 1961, Gagné and Paradise found support for the proposition that transfer of learning from subordinate sets of learning tasks could account for performance in a terminal learning task. In a subsequent study, Gagné, Mayor, Garstens, and Paradise (1962) sought to extend and confirm the validity of the idea of the "learning hierarchy."

Gagné, Mayor, Garstens, and Paradise (1962) sought to test effects of three factors that should mediate the effectiveness of learning hierarchies: (a) identifiability, which roughly translates into "acquisition of prerequisite concepts"; (b) recallability, stimulated in the study by cueing and repetition of prerequisite concepts; and (c) integration, in this study provided by what Gagné and Briggs later termed "provision of learning guidance," which was directed toward assisting the learner in applying concepts to problem situations. Two variables, used in various combinations, served to modify a basic learning program: repetition (high and low) and guidance (high and low). The posttest supplied information about achievement of not only the terminal task (adding integers) but also the 12 prerequisite learning sets, each

scored as "pass" or "fail." These data were analyzed to supply evidence of the effects of the treatments on transfer. Success in final task achievement correlated highly with the number of subordinate tasks successfully achieved for both of the two terminal learning tasks (.87 and .88). Patterns of transfer among the subordinate tasks also conformed to theoretical predictions.

In "The Acquisition of Knowledge," Gagné began by explicating the concept of a "class of tasks," differentiating the idea from "a response" by noting that in acquiring useful knowledge, it is inadequate to consider knowledge as a set of responses, since, when applied, it is impossible to identify from each specific response which skills, such as multiplication or punctuating compound sentences, the responses imply: "Any of an infinite number of distinguishable stimulus situations and an equal number of responses may be involved" (1962, p. 229).

18.3.4 Research Confirming Learning Hierarchies

In 1973, Gagné described the idea of learning hierarchies and noted that learning hierarchies have the following characteristics: (a) They describe "successively achievable intellectual skills, each of which is stated as a performance class"; (b) they do not include "verbal information, cognitive strategies, motivational factors, or performance sets"; and (c) each step in the hierarchy describes "only those prerequisite skills that must be recalled at the moment of learning" to supply the necessary "internal" component of the total learning situation (pp. 21–22).

Gagné also described several studies on the validation of learning hierarchies. A fundamental way to accomplish this is to look at differences in transfer between groups that attain and groups that do not attain hypothesized prerequisites. Gagné, Mayor, Garstens, and Paradise (1962, Table 3, p. 9) is cited as an example providing positive evidence from such an approach. Other validation studies were reported, each looking in one way or another at the validity of a particular learning hierarchy—in other words, at the extent to which the hierarchy was a true description of prerequisite relationships among hypothesized subtasks. As a set, these studies can be seen to present evidence to the validity of the concept of learning hierarchies. The studies are summarized in Table 18-2.

In addition to the above, studies by Gagné and associates commonly cited to support the learning hierarchies hypothesis include: Gagné, 1962; Gagné and Paradise, 1961; Gagné, Mayor, Garstens, and Paradise, 1962; Gagné and Bassler, 1963; Gagné and Staff, University of Maryland Mathematics Project, 1965.

It should be noted that in "Factors in Acquiring Knowledge of a Mathematical Task" and in "The Acquisition of Knowledge," Gagné dealt primarily with learning hierarchies, not yet with the idea that different types of learning might require different instructional conditions. The thrust of Gagné's ideas at this point was toward the organization and sequence of instruction, not toward the form of encounter.

18.3.5 Development of Events of Instruction and Conditions of Learning

18.3.5.1. Events of Instruction. In "The Acquisition of Knowledge" (Gagné, 1962), in addition to presenting the "learning hierarchies" concept, Gagné also introduced a precursor to the nine events of instruction. The description is of four functions that a theory of knowledge acquisition must account for:

1. Required terminal performance
2. Elements of the stimulus situation
3. High recallability of learning sets
4. Provision of "guidance of thinking"

Another foundation for the events of instruction was Gagné's thinking on the idea of internal and external conditions of learning, which is fundamental to the thesis of the first edition of *Conditions of Learning* in 1965. Internal and external conditions are defined (p. 21), and discussion of each of the types of learning is organized essentially along lines of internal and external conditions for achievement of that type of learning. To summarize his descriptions of these two types of conditions: Internal conditions were primarily described as learners' possession of prerequisite knowledge, and external conditions were viewed as instruction.

The first edition of *Conditions of Learning* (Gagné, 1965) did not have a discussion of the "events of instruction" in the

TABLE 18-2. RESULTS OF STUDIES ON HIERARCHIES

Author(s)	Date	Learning Task	Results
Wiegand	1970	inclined plane	transfer demonstrated
Nicholas	1970	not stated	replicated Wiegand
Coleman & Gagné	1970	exports comparison	too much mastery by ctrl. gp., but > transfer to prob. solv. found
Eustace	1969	concept "noun"	hypothesized sequence better
Okey & Gagné	1970	chemistry	lng. hier. revis. > orig. ver.
Resnick et al.	1971	double classification	successfully predicted outcomes
Caruso & Resnick	1971	replication	Resnick et al., 1971, confirmed
Wang et al.	1972	math curriculum	several dependency sequen. found

same fashion as the term later came to be used—as a listing intended to be inclusive, reflecting events that must occur, and if not supplied by instruction, generated by learners. The treatment in *Conditions of Learning,* under the heading "External Events of Instruction," included discussion of (a) control of the stimulus situation (strategy prescriptions varied with types of learning), (b) verbally communicated "directions" (directing attention, conveying information about expected performance, inducing recall of previously learned entities, and guidance in learning by discovery), and (c) feedback from learning.

The "events of instruction" conception may be more directly attributable to L. J. Briggs's work than Gagné's, although the two collaborated extensively on it. For example, Briggs, Campeau, Gagné, and May's (1967) handbook for "multimedia design of instruction" uses nearly all the elements of what was to become the "events of instruction" within its examples, but it does not present a list of the events (see Briggs, 1967, pp. 53–73; May & Briggs, 1967, pp. 74–138). In another chapter in that manual, Briggs, Gagné, and May noted (p. 45) as "instructional functions of stimuli," the following:

1. Set a goal in terms of performance desired.
2. Direct attention.
3. Present instructional content (also stimuli).
4. Elicit response.
5. Provide feedback.
6. Direct the next effort.
7. Help the student evaluate his performance.

Also noted here under "other special functions of stimuli" are: (a) providing the degree of cueing or prompting desired, (b) enhancing motivation, (c) aiding the student in recall of relevant concepts, (d) promoting transfer, and (e) inducing generalizing experiences (Briggs, Gagné & May, 1967, p. 45). Between the two lists, the events-of-instruction formulation appears to have been taking shape.

The first edition of *The Conditions of Learning* (Gagné, 1965) contained a section called "component functions of the instructional situation" that, except for the label, was to be virtually identical in conception and content to the "events of instruction" seen in later editions of *The Conditions of Learning,* as well as in Gagné & Briggs, *Principles of Instructional Design* (1974). The eight functions were: (a) presenting the stimulus, (b) directing attention and other learner activities, (c) providing a model for terminal performance, (d) furnishing external prompts, (e) guiding the direction of thinking, (f) inducing transfer of knowledge, (g) assessing learning attainments, and (h) providing feedback. With *Principles of Instructional Design* (Gagné & Briggs, 1974), the full Events of Instruction Model was first presented and fully discussed. Table 18.3 presents the Events of Instruction along with cross-reference to other sections in this handbook which relate to each section.

18.3.5.2. Conditions of Learning. Completing Gagné's contribution to conditions-based theory are his discussion of the internal and external conditions of learning that support each type of learning outcome. "Internal conditions" are those cognitive processes that support the acquisition of particular categories of learning outcomes. "External conditions" are those instructional conditions provided by teacher, materials, or other learners that can facilitate the internal conditions necessary for learning. These external conditions, too, vary according to type of learning. Not surprisingly, given Gagné's transition from behavioral to cognitive theory bases, he developed the external conditions model first.

As an instructional psychologist, Gagné was particularly interested in the external conditions that might occur or could be provided to "activate and support" the internal processing necessary for learning to occur (1985, p. 276). In fact, Gagné defined the purpose of instructional theory as "to propose a rationally based relationship between instructional events, their effects on learning processes, and the learning outcomes that are produced as a result of these processes" (1985, p. 244). Therefore, Gagné derived the external events from the internal events of information processing. (See Table 18.3.)

Gagné particularized the general external events, the "events of instruction," that begin to be described in his work in 1962 to specific prescriptions for external conditions for each type of learning, event by event, for each of the categories of learned capability. Much of these external conditions are logically derived from the intersection of the function of the external event (those cognitive processes that it supports) and the nature of the learned capability.

In "Domains of Learning" (1972), Gagné argued very specifically for a conditions-based theory but did not present research directly on it; rather, he presented arguments about the nature of different learning domains, buttressed often in a general fashion by research. The five domains—motor skills, verbal information, intellectual skills, cognitive strategies, and attitudes—are the level at which he argued that there is a difference in how they should be taught, particularly in terms of (a) the kind and amount of practice required and (b) the role of meaningful context. Additional criteria as means by which types of learning can be contrasted with regard to instructional concerns appear in a 1984 article, "Learning Outcomes."

In Gagné and White's 1978 article, two general domains of learning outcome were discussed: (a) knowledge stating and (b) rule application. References used to support the distinctness of these two domains include Gagné (1972) and Olson and Bruner (1974).

In 1987, Gagné and Glaser (1987) developed a review that included a brief survey of Gagné's early work, learning as cognition, importance of short-term memory, learning complex performances, knowledge organization for problem solving, mental models, and self-regulation. Table 18-4 (on p. 550), reproduced from that review, provides an excellent summary of hypothesized differential learning conditions for types of learning (see 5.3.5.4).

18.3.5.3. Internal Conditions of Learning. Gagné suggested that, for each category or subcategory of learning

TABLE 18-3. CROSS-REFERENCED GAGNÉ-BRIGGS (1974) EVENTS OF INSTRUCTION

Event	Handbook Cross-Reference
1. Gain attention	31.3.1, 34
2. Inform learner of objective	30.6.2
3. Stimulate recall of prerequisite learning	22.3.4.4
4. Presenting stimulus material	7.4, 11.3, 12.2.3, 13.4, 26–28, 31
5. Providing learning guidance	
6. Eliciting performance	30.6.1
7. Providing feedback	32
8. Assessing performance	7.47, 23.4.6
9. Enhancing retention and transfer	23.5.2.1

capability to be acquired, certain internal conditions were necessary. By 1985, Gagné described these internal conditions as two kinds: (a) prerequisite knowledge, which is stored in long-term memory, and (b) particular cognitive processes that bring this old knowledge and new knowledge together and store it in a retrievable form. Gagné described these cognitive processes using an information-processing model: attention, selective perception, semantic encoding, retrieval, response organization, control processes, and expectancies.

It should be noted that in Gagné's detailing of the internal conditions of each type of learning, the major internal condition that he described was prerequisite knowledge. For example, Gagné specifies the internal conditions for rule learning to be knowledge of (the ability to classify previously unencountered instances and noninstances of) component concepts. This may be because the research base for the identification of the specific internal conditions for each learning capability was inadequate or because as an instructional theorist, his predominant interest was the external conditions that could support the generalized information-processing mechanism and those internal conditions necessary prior to the initiation of new learning.

Gagné (1984) suggested that the internal events that may differ most across learning capabilities are "(a) the substantive type of relevant prior knowledge, (b) manner of encoding into long-term storage, (c) requirement for retrieval and transfer to new situations" (p. 514). Therefore, in his 1985 edition of *Conditions of Learning,* he pointed out that the events that may differ most significantly from learning category to learning category are those corresponding to the above three internal events: These external events are (a) stimulating recall of prior knowledge, (b) providing learning guidance, and (c) enhancing retention and transfer.

18.4 EXAMPLES OF CONDITIONS-BASED MODELS

Robert Gagné provided the intellectual leadership for a conditions-based theory of instruction. A number of scholars followed in his tradition by developing more detailed prescription of the external conditions that will support different types of learning.

The two texts edited by Reigeluth in the 1980s, *Instructional Design Theories and Models* (1983) and *Instructional Theories in Action* (1987), clearly delineate a number of models that we would describe as conditions-based models of design. (Some of the models in this text, such as those by Scandura, Collins & Keller, we would not describe as full conditions-based models, as they do not describe the cognitive and instructional conditions for more than one learning type.) It is not the purpose of this chapter to replicate the thorough discussions of the conditions-based models presented in Reigeluth (1983, 1987). However, we will briefly discuss and compare the models, because it is through the comparisons that many of the major issues regarding conditions-based models are revealed and exemplified. We will also briefly review research and evaluation studies that have examined the effectiveness of the model as a whole or individual features of the model. We have also included in our discussion some "models" not presented in Reigeluth's texts. Some examples provided are arguably not *instructional design models* at all (such as the work of Horn, 1976; Resnick, 1967; West, Farmer & Wolf, 1991), but all employ, reflect, or extend the *conditions-based theory* propositions listed in the introduction of this chapter in one important way or another.

18.4.1 Gagné and Gagné, Briggs, and Wager

We have thoroughly described Gagné's conditions-based theory of instruction elsewhere in this chapter. This theory was the basis of an instructional design model presented in Briggs's *Instructional Design: Principles and Applications* (1977) and *Principles of Instructional Design* (Gagné & Briggs, 1974, 1979; Gagné, Briggs & Wager, 1988, 1992).

Research examining the validity of Gagné's theory are of two types: those that have examined the validity of Gagné's instructional theory as a cluster of treatment variables and those that have examined the individual propositions of the theory as separate variables. Research of the latter type will be discussed later in this chapter. A few studies have attempted to evaluate the overall value of instruction based on Gagné's theory or portions of Gagné's theory that are not central to the conditions-based theory. We will describe several examples of studies of this first type. Goldberg (1987), Marshall (1987), Mengel (1986), and Stahl (1979) compared "traditional" textbook or teacher-led instruction to print-based or teacher-led instruction designed according to Gagné's principles. These studies were across age groups and subject matters. Mengal and Stahl found significant differences in learning effects for the versions developed

according to Gagné's principles, and for Goldberg and Marshall no significant difference in treatments. Although we believe such gross comparison studies to be essential to the development of research in an area, they suffer from some of the same threats to validity of conclusions as other comparison studies. In particular, it is unclear that the "traditional" versions did not include some features of Gagné's principles and that the "Gagnétian" versions were fully consistent with these principles. Research that has examined the principles from Gagné's instructional design models that are directly related to propositions of his theory will be discussed in a later section of this chapter.

18.4.2 Merrill: Component Display Theory

Merrill's (1983) Component Display Theory (CDT), an extension of Gagné's theory, is a conditions-based theory of instructional design, as he prescribed instructional conditions based on types of learning outcomes desired.

18.4.2.1. Types of Learned Capabilities. Merrill classified learning objectives (or capabilities) along two dimensions: performance level (remember, use, or find) and content type (facts, concepts, principles, or procedures). So, there are conceivably 12 distinct categories of objectives that his model addresses. Instead of having a declarative knowledge category, as Gagné does, which would include remembering facts, concept definitions, rule statements, and procedural steps, Merrill makes separate categories for each of these types of declarative knowledge. Similarly, instead of having a single cognitive strategies category as Gagné does, through his intersection of the two dimensions, Merrill proposes "find" operations for each of the content types: Find a fact, find a concept, find a rule, and find a procedure.

Merrill provided a rationale for his categorization scheme based on "some assumptions about the nature of subject matter" (p. 298). The rationale for content type is based on five operations that he proposes can be conducted on subject matter: identity (facts), inclusion and intersection (concepts), order (procedures), and causal operations (principles). He derived his performance levels from assumptions regarding differences in four memory structures: associative, episodic, image, and algorithmic. His performance levels derive from the associative (remember: verbatim and paraphrased) and algorithmic (use and find) memory structures. Merrill does not explicitly address the internal processes that accompany the acquisition of each of these categories of learning types.

18.4.2.2. External Conditions of Learning. Merrill described instructional conditions as "presentation forms" and classified these forms as primary and secondary. Primary presentation forms have two dimensions: content (generality or instance) and approach (expository or inquisitory). Secondary presentation forms are types of elaborations that may extend the primary presentations: context, prerequisite, mnemonic, mathemagenic help, representation or alternative representation, and feedback. Merrill's model then further describes for each category of capability" a unique combination of primary and secondary presentation forms that will most effectively promote acquisition of that type of objective" (p. 283).

18.4.2.3. Research on Component Display Theory. Researchers have examined component display theory in

TABLE 18-4. GAGNÉ AND GLASSER'S LEARNING CATEGORIES AND CONDITIONS SUMMARY

Effective Learning Conditions for Catagories of Learned Capabilities	
Type of Capability	Learning Conditions
Intellectual skill	Retrieval of subordinate (component) skills Guidance by verbal or other means Demonstration of applic. by student; precise feedback Spaced reviews
Verbal information	Retrieval of context of meaningful information Performance of reconstructing new knowledge; feedback
Cognitive strategy (problem solving)	Retrieval of relevant rules & concepts Successive presentation (usually over extended time) of novel problem situations Demonstration of solution by student
Attitude	Retrieval of information and intell. skills relevant to targeted personal actions Establishment or recall of respect for human model Reinforcement for personal action either by successful direct experience or vicariously by observation of respected person
	Motor Skill Retrieval of component motor chains Establishment or recall of executive subroutines Practice of total skill; precise feedback (Gagné & Glaser, 1987, p. 64)

two ways: evaluation in comparison to "traditional" approaches and examination of individual strategy variations within component display theory. We briefly describe examples of both types of research.

In research across a range of content, age groups, and learning tasks, researchers have examined the effectiveness of instruction following design principles proposed by component display theory to existing or "traditional" instruction. For example, Keller (1982) compared more conventional mathematics instruction in both expository and discovery formats to instruction following a "modified discovery" approach suggested by CDT. Keller found no significant effects on acquisition of set theory concepts, concluding that is was important to learning that the generality be presented explicitly, but less important whether this generality was presented prior to or following presentation of examples. In contrast, Stein (1982) found a superiority of CDT for concept learning among eighth-grade learners, comparing four treatments: expository prose, expository prose plus adjunct questions, CDT with only primary presentation forms, CDT with both primary and secondary presentation forms. She found that both CDT versions were significantly more effective in promoting students' ability to recognize previously presented instances of these concepts and to generalize the concept to previously unencountered instances. In addition, she found that this effect was more pronounced for the more difficult concepts. In a similar prose study, Robinson (1984) found a CDT version of a lesson on text editing to be significantly superior (on recall of the procedure, marginally on use of the procedure [p = .11]) to two other versions of prose instruction: one version with summarizing examples, one version with inserted questions. Van Hurst (1984) found a similar positive effect of materials revised using CDT principles when compared with the existing instructional materials in Japanese language learning. The CDT version was found to promote significantly greater achievement and more positive affect and confidence than the original version.

Researchers have also examined individual variables in component display theory. For example, Keller (1985) examined the relative benefits of generality alone, best example alone, or both generality and best example on learning graphing concepts and procedures. She found that the combined treatment was superior for remembering the steps in the procedure. None of the treatments was superior for using the procedure (only practice seemed to be critical). Further, the combined condition was superior for promoting finding a new procedural generality. Chao (1983) also examined the benefits of two expository versions of CDT (generality, example, practice, generality/generality, example, practice) and two discovery treatments (examples, practice/examples, practice, generality) on application and transfer of concepts and principles of plate tectonics. Unlike Chao and similar to her earlier comparisons of expository and discovery sequences (1982), Keller found no statistically significant difference in the participants' performance on application or transfer measures. Although order of generality, example, and practice may not be found to affect performance, Sasayama (1984) found that for a procedure-using learning task, a rule-example-practice treatment had superior effects on learning than a rule-only, example-only, or rule-example treatment.

Many of the weaknesses of Merrill's model are similar to those of Gagné's, such as lack of an explicit and empirically validated tie between internal processes and external events. However, Merrill's model conjectures even less on internal processes. It is also less complete, as his model addresses only the cognitive domain, does not fully delineate the instructional conditions for the "find" (cognitive strategies) category, and does not have a category for complex learning reflected in what is often called "problem solving." A strength of CDT may be its evolution to fit with the demands of designing intelligent CAI systems, as noted by Wilson (1987).

18.4.3 Reigeluth: Elaboration Theory

Reigeluth and his associates (Reigeluth, Merrill & Wilson, 1978; Reigeluth & Darwazeh, 1982; Reigeluth & Rogers, 1980; Reigeluth & Stein, 1983) developed the elaboration theory as a guide for developing macrostrategies for large segments of instruction, such as courses and units. The elaboration theory is conditions based in nature as it describes (a) "three models of instruction and (b) a system for prescribing those models on the basis of the goals for a whole course of instruction" (p. 340). His theory specifies a general model of selecting, sequencing, synthesizing, and summarizing content in a simple to more complex structure. The major features of the general model are an epitome at the beginning of the instruction, levels of elaboration of this epitome, learning-prerequisite sequence within level of elaboration, a learner-control format, and use of analogies, summarizers, and synthesizers.

The conditions-based nature of the model is obtained from Reigeluth's specification of three differing structures—conceptual, procedural, or theoretical—which are selected based on the goals of the course. Reigeluth further suggested that conceptual structures are of three types: parts, kinds, or matrices (combinations of two or more conceptual structures). He described two different kinds of procedural structures: procedural order and procedural decision. Finally, he subdivided theoretical structures into two types: those that describe natural phenomena (descriptive structures) and those that affect a desired outcome (prescriptive structures).

The nature of the epitome, sequence, summarizers, perquisites, synthesizers, content of elaborations will vary depending on the type of knowledge structure chosen, which was based on the goals of the course. For example, if the knowledge structure is conceptual, the epitome will contain a presentation of the most fundamental concepts for the entire course. If the structure is procedural, the epitome should present the most fundamental or "shortest path" pro-

cedure. Reigeluth recommended use of Merrill's component display theory as the guideline for designing at the micro or lesson level within each elaboration cycle.

In recent years, Reigeluth (1992) has placed more emphasis on the importance of using a simplifying conditions method (SCM) of sequencing instruction than on the sequencing and structuring of instruction based on one of the major knowledge structures. The simplifying conditions method suggests that designers "work with experts to identify a simple case that is as representative as possible of the task as a whole" (p. 81). This task should serve as the epitome of the course with succeeding levels of elaborating "relaxing" the simplifying conditions so that the task becomes more and more complex. The theory still retains some of its conditions-based orientation, though, as Reigeluth has suggested, different simplifying conditions structures need to be developed for each of the kinds of knowledge structures he described (Reigeluth & Rogers, 1980; Reigeluth, 1987).

18.4.3.1. Research on Elaboration Theory. As with the previous models, some research has evaluated the effectiveness of instruction based on the principles of elaboration theory in comparison to instruction designed based on other models. Examples of this type of research are Beukhof (1986), who found that instructional text designed following elaboration theory prescriptions were more effective than "traditional" text for learners or learners with low prior knowledge. In contrast, Wagner (1994) compared instruction on handling hazardous materials designed using the elaboration theory to materials designed using structural learning theory (Scandura, 1983). She found that although it took longer for learners to reach criterion performance with the structured learning materials, they performed significantly better on the delayed posttest than learners in the elaboration theory group. Wedman and Smith (1989) compared text designed according to Gagné's prescriptions and following a strictly hierarchical sequence to text designed according to the elaboration theory. They found no significant differences in either immediate or delayed principle application (photography principles). Nor did they find any interactions with a learner characteristic, field independence/dependence. In another study using the same materials, Smith and Wedman (1988) found some subtle differences between the read-think-aloud protocols of participants from the same population who were interacting with the two versions of the materials. They found that participants interacting with the elaborated version (a) required less time per page than the hierarchical version, (b) made more references to their own prior knowledge, (c) made fewer summarizing statements, (d) used mnemonics less often, and (e) made about the same types of markings and nonverbal actions as participants interacting with the hierarchical version. They concluded that although instruction designed following the two different approaches may evoke subtle processing differences, these differences are not translated into differences in immediate and delayed principle application, at least within the 2 hours of instruction that this study encompassed. As Reigeluth proposes that the elaboration theory is a macrostrategies theory, effective for the design of units and courses, and recommends component display theory as a microdesign strategy for lessons, it is perhaps not surprising that researchers have not uniformly found positive effects of the elaboration theory designs with their shorter instruction.

Researchers have also examined design questions regarding individual variables within elaboration theory, such as synthesizers, summarizers, nonexamples in learning procedures, and sequencing. Table 18-5 below summarizes the findings of several of these studies.

18.4.3.2. Evaluation of Elaboration Theory. Elaboration theory is a macrostrategy design theory that was much needed in the field of instructional design. Throughout the evolution of elaboration theory, Reigeluth has proposed design principles that maintained a conditions-based orientation. Due to the strong emphasis on learning hierarchy analysis, until Reigeluth's work many designers had assumed that instruction should proceed from one enabling objective to another from the beginning to the end of a course. Reigeluth suggested a theoretically sound alternative for designing large segments of instruction. It is unfortunate that researchers in the field have not found it pragmatically possible to evaluate the theory in comparison to alternatives with course-level instruction.

In light of advances in cognitive theory, Wilson and Cole (1992) suggested a number of recommendations for revising elaboration theory. These suggestions include (a) deproceduralizing the theory; (b) removing unnecessary design constraints (including the use of primary structures, which form the basis of much of the conditions-based aspect of elaboration theory); (c) basing organization and sequencing decisions on what is known by the learners as well as content structure; and (d) assuming a more "constructivist stance" toward content structure and sequencing (p. 76). Reigeluth (1992) responded to these recommendations in an admirable way: Regarding the deproceduralization of the elaboration theory, he pointed out that he agreed that the theory itself should not be proceduralized, but that he has always included in his discussions of ET ways to operationalize it. Reigeluth proposes that he has already removed "unnecessary design constraints" (the second Wilson & Cole recommendation) by replacing the "content structure" approach by the simplifying conditions method. This approach may more nearly reflect Reigeluth's original intentions for the elaboration theory. However, it does not eliminate the underlying conditions-based principle (which we interpret Wilson & Cole to be recommending), as the method for identifying simplified conditions seems to vary according to whether the instructional goal is conceptual, theoretical, or procedural. Reigeluth concurs with Wilson and Cole's recommendation to take the learners' existing knowledge into account in the elaboration theory, although beyond some revision in the sequencing of conceptual layers (from the middle out, rather than top down), he does not propose that this will be formalized in his theory. Regarding the recommendation that he assume a more "constructivist stance," Reigeluth concurs that this may be important in ill-structured

TABLE 18-5. STUDIES EXAMINING ELABORATION THEORY VARIABLES

Author(s)	Date	Variables	Findings
McLean	1983	Types of synthesizers : visual, verbal, both, none	Visual > verbal or none for remembering relationships Visual & verbal > none for remembering relationships
Chao & Reigeluth	1983	Types of synthesizers: visual/verbal, lean or rich	NSD for visual/verbal rich> lean for remember level
Van Patten	1983	Location of synthesizers: internal, external (pre), external (post)	NSD
Carson & Reigeluth	1983	Location of synthesizers	Post > pre
Tilden	1985	Types of summarizers	GPA X summarizer interaction (richer better for low GPA)
Carson & Reigeluth	1983	Sequencing of content: gen. to detail/ detail to gen.	Gen. to detail > detail to gen.
Van Patten	1983	Sequencing of content: gen. to detail/ simple to complex	NSD
Bentti, Golden & Reigeluth	1983	Non-egs in teaching procedures	Greater divergence of non-egs > less & diverg. Clearly labeled non-egs > nonlabeled
Garduno	1984	Presence/absence of non-egs in teaching procedures	NSD
Marcone & Reigeluth	1988	Non-egs in egs or generalities in teaching procedures	non-egs in generality > non-egs in eg form
Beissner & Reigeluth	1987	Integration of content structures	Can be effective
Jackson	1993	Presence/absences of ET elements	Not all equally effective
English & Reigeluth	1994	Formative research of ET	Suggestions for sequencing and construction of epitome

domains, which the elaboration theory does not currently address. However, he insightfully suggests, "People individually construct their own meanings, but the purpose of instruction—and indeed of language and communication itself—is to help people to arrive at shared meanings" (p. 81).

18.4.4 Landa

In terms of learning outcome types, Landa's (1983) algo-heuristic theory of instruction, or "Landamatics," makes a distinction between knowledge and skills (ability to apply knowledge): categories that seem to be equivalent to declarative and procedural knowledge. According to Landa, learners acquire *knowledge* about objects and operations. Objects are known as a perceptive image, i.e., as a mental image or as a concept. A concept can be expressed as a proposition, but it is not necessary that a concept be expressed in order to be known. There are other kinds of propositions such as definitions, axioms, postulates, theorems, laws, and rules which can form a part of knowledge. Operations (action on an object) are transformations of either real material objects or their mental representations (images, concepts, propositions). A skill is the ability to perform operations. Operations that transform material objects are motor operations. Operations that transform materials objects are cognitive operations. Operations can be algorithmic, "a series of relatively elementary operations that are performed in some regular and uniform way under defined conditions to solve all problems of a certain class" (p. 175), or heuristic, operations for which a series of steps can be identified but are not so singular, regularized, and predictable as algorithms. Algorithmic operations appear similar to Merrill's conception of procedures, and the heuristic operations appear similar to Smith and Ragan's treatment of procedural rules and Gagné's problem solving (higher-order rule). A critical aspect of Landa's model is the importance that he ascribes to the verification of hypothetical description of algorithmic or heuristic process through observation, computer simulation, or error analysis. Such empirical validation is present in specifics of design models in task analysis but is generally missing in conditions-based models

with regard to a generalized hypothetical cognitive task analysis for each class of outcomes that can be directly related to prescriptions for external conditions of learning.

Landa's theory suggests how to support processes that turn knowledge into skills and abilities, a transition that provides much of the substance of Anderson's (1985) ACT* theory. He suggests the following conditions for teaching individual operations:

1. Check to make sure that the learners understand the meaning of the procedure.
2. Present problem that requires application of the procedure.
3. Have the student name the operation or preview what should be done to execute the operation.
4. Present next problem.
5. Practice until mastery.

Although he suggests a procedure for teaching students to discover procedures (algorithms), he points out that this process is difficult and time consuming.

18.4.4.1. Research and Evaluation. Research on Landa's model is not as readily available in the literature as the previously reviewed models. However, Landa has reported some evaluation of his model in comparison with more "conventional" training. Landa (1993) estimated that he has saved Allstate $35 million in costs due to (a) many times fewer errors (up to 40 times fewer), (b) tasks performed up to 2 times faster, and (c) workers' confidence level several times higher.

18.4.5 Smith-Ragan

Rather than developing a new conditions-based model, Smith and Ragan (1993) sought to exemplify and elaborate Gagné's theory. To address what they perceived to be limitations in most conditions-based models, they postulated a generalized cognitive process necessary for the acquisition of each of the different learning capabilities. With regard to the external conditions of learning, Smith and Ragan suggested that events of instruction as Gagné portrayed them insufficiently considered learner-generated and learner-initiated learning. Smith and Ragan restated the events so that they could be perceived as either learner-supplied, in the form of learning strategies, or instruction-supported, in the form of instructional strategies.

Smith and Ragan also proposed a model for determining the balance between instructional strategies (instruction-supplied events) and learning strategies (learner-supplied events) based on context, learner, and task variables. They also proposed that there is a "middle ground" between instruction supplied, supplantive (also know as *mathemagenic*) events (see 30.6), and learner-initiated events (see 33.2), in which the instruction facilitates or prompts the learner to provide the cognitive processing necessary to an instructional event.

18.4.5.1. Research and Evaluation. Smith (1992) cited theoretical and empirical bases for some of the learner-task-context-strategy relationships proposed in the COGSS model, which forms the basis of the balance between instruction-supplied and learner-generated events. In this presentation she proposed an agenda for validation of the model.

18.4.6 Tennyson and Rasch

Tennyson and Rasch (1988) described a model of how instructional prescriptions might be tied to cognitive learning theory. This work was preceded by a short paper by Tennyson (1987) which contained the key elements of the model. In this paper, part of a symposium on Clark's "media as mere vehicles" assertions, Tennyson discussed how one might "trace" the links between different treatments that media might supply and different learning processes. He described six learning processes (three storage processes: declarative knowledge, procedural knowledge, and conceptual knowledge; and three retrieval processes: differentiating, integrating, and creating) which he paired with types of learning objectives, types of knowledge bases, instructional variables, instructional strategies, and computer-based enhancements.

Tennyson and Rasch (1988a, b) and Tennyson (1990) suggested that kinds of learning should refer to types of "memory systems." As with the previous conditions-based models, Tennyson and Rasch employed an information-processing model as their foundation and suggested the main types of knowledge to be: (a) declarative, which is stored as associative networks or schemata and relates to verbal information objectives; (b) procedural, which relates to intellectual skills objectives; and (c) contextual, which relates to problem-solving objectives and knowing when and why to employ intellectual skills. Five forms of objectives are described as requiring distinct cognitive activity (verbal information, intellectual skills, conditions information, thinking strategies, and creativity). In discussing the relationships among the types of knowledge, Tennyson and Rasch noted that contextual knowledge is based on "standards, values, and situational appropriateness. . . . Whereas both declarative and procedural knowledge form the amount of information in a knowledge base, contextual knowledge forms its organization and accessibility" (Tennyson & Rasch, 1988a, p. 372).

In terms of instructional conditions, for declarative knowledge they recommended expository strategies, such as worked examples, which provide information in statement form on both the context and structure of information and question/problem repetition, which presents selected information repeatedly until the student answers or solves all items at some predetermined level of proficiency. For procedural knowledge, they recommended practice strategies in which learners apply knowledge to unencountered situations and some monitoring in terms of evaluation of learner responses and advisement. To teach contextual knowledge, they suggested problem-oriented simulation techniques. And for complex problem situations, they recommended a simulation in which the consequences of decisions update the situational conditions and proceed to make the next iteration more complex.

An interesting element is a prescription of learning time for the different types of learning: 10% for verbal information, 20% for intellectual skills, 25% for conditional information, 30% for thinking strategies, and 15% for creativity. One intent of this distribution was to reflect Goodlad's (1984) prescription of a reversal of traditional classroom practice from 70% of instructional time devoted to declarative and procedural knowledge and only 30% to conceptual knowledge and cognitive abilities. Although such general proportions may serve to illuminate general curriculum issues, specification of percentages of time to types of learning, regardless of consideration of other factors in a particular learning situation, may find limited applicability to instructional design.

18.4.6.1. Research and Evaluation. Tennyson and Rasch's model has not yet been subjected to evaluation and research. In terms of the extension of conditions-based models, some issues do emerge. Although other theorists propose this conditional knowledge, it is unclear whether the addition of a contextual type of learning will enhance the validity of the model. It is possible that such knowledge is stored as declarative knowledge that is in some way associated with procedural knowledge, such as in a mental model or problem schema. The suggestion of time that should be allocated to each type of learning is intriguing, as it attempts to point out the necessity of emphasis on higher-order learning. However, the basis for determination of the proportion of time that should be spent on each type of outcome remains unclear.

18.4.7 Merrill, Li, and Jones—ID2

In reaction to a number of limitations that they perceived in existing instructional design theories and models (including Merrill's own), Merrill, Li, and Jones (1990a, 1990b) have set about to construct a "second-generation theory of instructional design." One of the specific goals of its developers is to expedite design of an automated ID system, "ID Expert," and thereby expedite the instructional design process itself. Ultimately, the developers hope that the system will possess both authoring and delivery environments that grow from a knowledge and rule base. Of all the models described in this chapter, ID2 is the most ambitious in its goal to thoroughly prescribe the instructional conditions for each type of learning. The ID2 model is being developed to (a) analyze, represent, and guide instruction to teach integrated sets of knowledge and skill; (b) produce pedagogic prescriptions about selection and sequence; and (c) be an open system that can respond to new theory. This model has retained its conditions-based orientation. Indeed, Merrill and his associates (p. 8) have elaborated on the relationships between outcomes and internal/external conditions:

> (a) A given learned performance results from a given organized and elaborated cognitive structure, which we will call a mental model. Different learning outcomes require different types of mental models; (b) the construction of a mental model by a learner is facilitated by instruction that explicitly organizes and elaborates the knowledge being taught, during the instruction; (c) there are different organizations and elaborations of knowledge required to promote different learning outcomes.

Within ID2, outcomes of instruction are considered to be enterprises composed of entities, activities, or processes, which might loosely be interpreted as concepts, procedures, and principles, respectively. Merrill and his associates have spent a vast amount of effort describing the structure of knowledge relating to these types of knowledge and how these types of knowledge relate to each other.

Merrill and associates have described a number of conditions (external conditions or instructional methods) that can be placed either under either system or learner control. These conditions are described as "transactions" of various classes. Evidence of Merrill's component display theory can be found in the prescriptions for these transactions. To create this system based on his ID2, Merrill and his colleagues (1991, 1992a, b, c) have attempted to identify the decisions that designers must make regarding the types of information to build into the system and the methods by which this information can be made available to learners. This analysis is incredibly detailed in and of itself. For example, Table 18-6 summarizes the "responsibilities" of the transactions that may be made available in instruction, the "methods" that make up these responsibilities, and the range (or parameters) of these methods. Merrill et al. have made similar analyses of information that may be made available to learners when learning entities, activities, or processes. In addition to detailing the options of pedagogy and information that can be made available in instruction, the developers of a system may also establish the "rules" by which system choices may be made as to which of these options to present to learners.

18.4.7.1. Research and Evaluation. Parts of the system been evaluated by Spector and Muraida (1991) and by Canfield and Spector (1991). For example, one of the major evaluation questions has been: "Can the target audience of novice designers use the system, and can this system expedite instructional design activities?" In Spector and Muraida's study, investigating the utility of the system to expedite design, eight subjects participated in 30 hours of instruction in which they learned to use the system and developed 1 hour of instruction. The results indicated that all subjects who remained in the study were able to complete a computer-based lesson using the support of a portion of the system.

As yet there are no comparison data with more conventional design processes. In their effort to carefully explicate necessary knowledge for learning and instruction, as well as the means by which these interact with each other, the developers have created a model that is quite complex. One benefit of the model is that its complexity reflects and makes concrete much of the complexity of the instructional design process. Unfortunately, it seems that terminology has shifted during development. ID2 is not without its critics. Among criticisms frequently leveled are its utility when used by novices, the lack of evidence of theory base, issues regarding

TABLE 18-6. SUMMARY OF ID2 INSTRUCTIONAL TRANSACTION RESPONSIBILITIES

Method	Parameters
Select knowledge	Selection control (learner, system)
Partition knowledge	Partition control (learner, system) Focus (entire entity or component of entity) Levels (amount of knowledge cluster below focus to include) Coverage (all, user identifies)
Portray knowledge	Portrayal control (learner, system) View (structural, physical, functional) Mode (language, symbolic, literal) Fidelity (low to high)
Amplify knowledge	Ancillary information control (learner, system) Ancillary information mode (verbal, audio) Pronunciation availability (no, system, learner) Pronunciation mode (verbal, audio) Component function availability (no, learner, system) Component function mode (verbal, audio) Component description availability (no, learner, system) Component description mode (verbal, audio) Component aside available (no, learner, system) Component aside mode (verbal, audio)
Sequence knowledge	Sequence control (learner, system)
Route learner	Segment sequence control (learner, system) Segment sequence type (elaboration, cumulation, accrual, learner) Depth (depth first, breadth first) Accrual (all, isolated part, replacement) Priority (chronological, frequency, criticality, familiarity)
Guide advancement	Shift segment on (learner, repetitions, practice, criterion, assessment criterion) Repetitions Criterion
Manage interaction	Management control (learner, system)
Prioritize interactions	Strategy control (learner, system) interaction strategy type (overview, familiarity, basic, mastery, basic-remediation, mastery-remediation, learner)
Expedite acquirement	Shift interaction on (learner, repetitions, criterion, response time, elapsed time) Repetition Criterion Response time Elapsed time
Enact interactions	Enactment control (learner, system)
Overview knowledge	Overview control (learner, system) Overview view (structure, + focus, + level 1) Structure format (tree, browser)
Present knowledge	Presentation display element control (learner, system) Presentation display element availability (label, function, properties) Presentation display element timing (untimed, *n* seconds) Presentation display element sequence (order, simultaneous, sequential)
Enable practice	Practice formats (locate, label, function, properties) Practice format sequence (sequential, simultaneous) Response mode (recall, recognize) Response timing (untimed, *n* seconds) Practice format control (learner, system) Response repetition (*n*, contingent) Component order (learner, same, random) Feedback availability (yes, no) Feedback type (intrinsic, correct ans., right-wrong, attn. focusing, designer specific) Feedback control (learner, system) Feedback timing (immediate, schedule, delayed) Feedback schedule type (fixed interval, variable interval, fixed ratio, variable ratio)
Assess knowledge	

sufficient agreement to generate strategies, and the likelihood of sameness of results in multiple applications.

18.4.8 Other Applications of Conditions-Based Theory

Although they have not sought to develop complete instructional design models, a number of notable scholars within and outside the instructional design field have utilized a conditions-based theory as a basis for much of their work. We will briefly describe four of these examples; they illustrate how pervasive and influential the conditions-based theory has been.

18.4.8.1. Jonassen, Grabinger, and Harris. Jonassen, Grabinger, and Harris (1991) developed a decision model for selecting strategies and tactics of instruction based on three levels of decisions: (a) scope (macro/micro); (b) instructional event (prepare learner, present information, clarify ideas, provide practice, and assess knowledge); and (c) learning outcome. Levels (b) and (c) are similar to the decisions patterns suggested by Gagné and Gagné and Briggs.

Jonassen, Grabinger, and Harris recommended making decisions regarding instructional tactics based on three major categories of learning outcomes: intellectual skills (concept or rule), verbal information, or cognitive strategy (iconic, verbal/digital). They suggested prescriptions for instructional events based on the learning outcome—for example, for the event of preparing the learning by supporting recall of prior knowledge of intellectual skills through presenting a verbal/oral comparative advance organizer, adapting content of instruction to learners' prior knowledge, and reviewing prerequisite skills and knowledge. This work has been elaborated into a more complete outcomes-based model for formatively evaluating instruction (Jonassen & Tessmer, 1996).

18.4.8.2. Horn. Horn's approach to text design has many elements of a design model and clearly employs a conditions-based set of assumptions. Horn's work, called *structured writing,* presents a highly prescriptive approach to the design of instructional and informative text. In addition to format concerns, Horn proposed different treatments for different types of learning. The types of learning he identified are procedures (which explain how to do something and in what order to do it); structure (about physical things, objects that have identifiable boundaries); classification (which shows how a set of concepts is organized); process (which explains how a process or operation works, how changes take place in time); concepts (which define and give examples and nonexamples of new aspects of the subject matter), and facts (which give results of observations or measurements without supporting evidence) (Horn, 1976, p. 17). Horn described differential conditions for text presentation by identifying what elements (or "blocks") each presentation relating to a particular type of learning (or "map") must have. Horn differentiated between necessary and optional elements for each type of learning.

18.4.8.3. West, Farmer, and Wolf. West, Farmer, and Wolf (1991) referred to three kinds of knowledge: (a) declarative, which is stored in propositional networks that may be semantic or episodic and may structured as data or state schemata; (b) procedural knowledge that is order-specific and time-dependent (p. 16), and (c) conditional knowledge, which is knowing when and why to use a procedure (similar to Tennyson & Rasch's "contextual knowledge"). They describe "cognitive strategies" that can support the acquisition of each of these learning types, which the instructional designer plans instruction to activate. In contrast to Gagné, who typically portrays cognitive strategies as instructional strategies, supplied by instruction, and in contrast to Smith and Ragan (1993), who portray the primary load of information processing as something that should shift between learner and instruction depending on circumstances, West, Farmer, and Wolf imply that strategies are always provided by the learner. These cognitive strategies are chunking, frames (graphic organizers, concept mapping, advance organizer, metaphor, rehearsal, imagery, and mnemonics). In terms of prescriptive or conditions-based models, West, Farmer, and Wolf prescribe the strategies as effective to support acquisition of all types of knowledge. However, they also use Gagné's five domains as types of outcomes for prescribing the appropriateness of each strategy, which is somewhat confusing, as procedural knowledge and intellectual skills, which are usually considered to refer to the same capabilities, are not given the same prescriptions for strategies. Our evaluation is that their prescriptions are for the declarative portion of higher-order knowledge types.

18.4.8.4. E. Gagné. Unlike most instructional models, E. Gagné's work (1993) is primarily descriptive, rather than prescriptive. E. Gagné based her conditions-based propositions on J. Anderson's (1990) cognitive theories of learning, and placed her theory base within the information-processing theories. She subscribed to Anderson's types of knowledge: declarative and procedural. Gagné described the representations of declarative knowledge as propositions, images, linear orderings, and schemas (which can be composed of propositions, images, and linear orderings). Procedural knowledge is represented as a production system, which can result in domain-specific skills, domain-specific strategies, and, to a limited degree, domain-general strategies.

Although the majority of her text is more descriptive than prescriptive, E. Gagné utilized the conditions-based theory as she discussed the internal processes required in the acquisition of each of the types of knowledge and the instructional support that can promote this acquisition. She described instructional support as increasing the probability that required processes will occur, or making learning easier or faster.

A strength of E. Gagné's formulation is her description of internal processes. In addition, she provides empirical evidence of effectiveness of instructional support conditions.

18.5 AN EXAMINATION OF THE PROPOSITIONS OF A CONDITIONS-BASED THEORY

As noted in introduction to this chapter, the primary propositions of conditions-based theory can be summarized to four main assertions: (a) Learning goals can be categorized as to learning outcome or knowledge type; (b) related to (a), different outcome categories require different internal conditions (or, one can view the proposition as "different internal conditions leading to different cognitive outcomes"); (c) outcomes can be represented in a prerequisite relationship; (d) different learning outcomes require different external conditions for learning. In this section, issues relating to each of the primary propositions will be discussed.

18.5.1 Learning Outcomes Can Be Categorized

What is meant by a learning outcome? The meaning we attribute to "outcomes" differs depending on whether we perceive these outcomes as external (as a category of task or goal) or internal (as an acquired capability, perhaps supported by a unique memory system). Gagné (1985) clearly described his classification system of outcomes as "acquired capabilities," an internal definition. Merrill (1983) has described his outcome categories as "performances," "categories of objectives," and "learned capabilities," rather a mix of internal and external connotations. Reigeluth's categorization is of "types of content," which somewhat implies the categorized of an external referent. Landa describes his kinds of knowledge as "psychological phenomena," suggesting an internal orientation. Clearly, there is no consensus even within the models described in this chapter as to what the term *learning outcomes* actually implies. Indeed, the evidence to support the validity of each category system would vary in its type and complexity, depending on whether the phenomena are viewed as entities "out there" that can be pinned down and observed, or "within," where we only see circumstantial evidence of their presence.

The statement "learning outcomes can be categorized" is both a philosophical and psychological assertion. Indeed, both philosophers, such as Ryle (1949), and psychologists, such as Anderson (1990), have posited ways to categorize knowledge. Interestingly, Ryle and Anderson agreed on a similar declarative/procedural classification system. Certainly, instructional theorists have suggested a variety of category systems. (However, most are compatible with the declarative/procedural classification. Gagné certainly adds additional categories to these: attitude, motor skill, and, perhaps, cognitive strategies. Tennyson and Rasch add a third class of learning, contextual knowledge.) For each group, the philosopher, the psychologist, and the instructional theorist, the evidence for the "truth" of the proposition would vary. For philosophers, this is an epistemological question, and the manner for determining its truth would depend on the philosophic school to which a particular philosopher ascribes. We will not pursue this approach for determining the validity of our assertion directly.

Reigeluth (1983) suggests a utility criterion for determining whether a categorization system is appropriate:

> When we say concepts are human-made and arbitrary, we mean phenomena can be conceptualized (i.e., grouped or categorized) in many alternative ways. . . . Practically all classification schemes will improve our understanding of instructional phenomena, but concepts are not the kind of knowledge for which instructional scientists are looking, except as a stepping stone. Instructional scientists want to determine *when* different methods should be used—they want to discover principles of instruction—so that they can prescribe optimal methods. But not all classification schemes are equally useful for forming highly reliable and broadly applicable principles. . . . The same is true of classes of instructional phenomena: Some will have high *predictive usefulness* and some will not. The challenge to our discipline is to find out which ones are the most useful (pp. 12–13).

The psychologist would want empirical evidence that the categories are distinct, which leads to our second proposition.

18.5.2 Different Outcome Categories Require Different Internal Conditions

Most of the models within the conditions-based theory propose that learning categories are different in terms of cognitive-processing demands and activities. All of the major seven design models described in this chapter appear to make this assumption, to a greater or lesser degree. Although all models in this chapter suggest that a general information-processing procedure occurs in learning, they also suggest that this processing significantly and predictably differs for each of the categories of learning that they have identified. For example, R. Gagné suggested that in particular the cognitive processes of retrieval of prior knowledge, encoding, and retrieval and transfer of new learning would differ significantly in nature, depending on the type of learning goal. Indeed, several of the model developers, including Tennyson and Rash (1988), R. Gagné (1985), Merrill (1983), and Smith and Ragan (1993), postulated different memory structures for different types of learning outcomes.

A slightly different statement of the proposition allows for a closer relationship to the first proposition (outcomes can be categorized): Different internal conditions lead to different cognitive outcomes. This more descriptive (and less prescriptive) assertion seems to be supported by additional educational theorists. For example, both Anderson (1990) and E. Gagné (1993) propose that different cognitive processes lead to declarative and procedural learning. They also propose that these two types of learning have different memory systems, schemata for declarative knowledge and productions for procedural learning. They both provide some empirical evidence that these cognitive processes and storage systems are indeed unique to the two types of learning.

We must point out that even if connectionists (Bereiter, 1991) are correct, that there is only one memory system (neural networks) and only one basic cognitive process (pattern recognition), this does not necessarily preclude the possibility of different types of learning capabilities. For example, there may be generalized activation patterns that represent certain types of learning.

18.5.3 Outcomes Can Be Represented in a Prerequisite Relationship

Gagné's work on learning hierarchies would appear to be sufficient to confirm this assumption rather resoundingly, as reported previously in this chapter. In addition to work by Gagné and others working directly in his tradition, research by individuals working from entirely different frames of reference appears also to solidly confirm this assumption.

Although early learning hierarchy research appeared highly confirmatory, R. T. White developed an important review of learning hierarchy research in the early 1970s (White, 1973). In this review, studies validating the idea of learning hierarchies were sought. Due to methodological weaknesses, White found no studies that were able to validate a complete and precise fit between a proposed learning hierarchy and optimal learning: "All of the studies suffered from one or more of the following weaknesses: small sample size, imprecise specification of component elements, use of only one question per element, and placing of tests at the end of the learning program or even the omission of instruction altogether" (White, 1973, p. 371).

In research following White's review, research that applied his recommendations to correct methodological weaknesses, a series of studies providing confirmation of the learning hierarchy formulation were published. (White 1974a, b, c; Linke, 1973) These results led Gagné to conclude: "The basic hypothesis of learning hierarchies is now well established, and sound practical methods for testing newly designed hierarchies exist" (White & Gagné, 1974, p. 363). Other research from what may be considered within the Gagné tradition which appears to confirm the learning hierarchy hypothesis includes Resnick, 1967; Resnick and Wang, 1969; Merrill, Barton, and Wood, 1970; and Linke, 1973.

Work on learning hierarchies from outside the Gagné tradition or a conditions theory perspective includes studies by Winkles, Bergan, and associates, and Kallison. Winkles (1986) investigated the learning of trigonometry skills with a learning hierarchy validation study identifying both lateral and vertical transfer. Two experiments with eighth- and ninth-grade students involved instructional treatments described as "achievement with understanding" and "achievement only." Results reported "achievement with understanding treatment is better for the development of lateral transfer for most students, and of vertical transfer for the more mathematically able students, whereas the differences between the treatment groups on tests of achievement and retention of taught skills are not significant. A small amount of additional instruction on vertical transfer items produces much better performance under both treatments" (p. 275).

Bergan, Towstopiat, Cancelli, and Karp (1982), also not working from the conditions tradition, reported a study that provided what appears to be a particularly interesting form of confirmation of the learning hierarchy concept and some insights into rule learning:

> This investigation examined ordered and equivalence relations among hierarchically arranged fraction identification tasks. The study investigated whether hierarchical ordering among fraction identification problems reflects the replacement of simple rules by complex rules. A total of 456 middle-class second-, third-, and fourth-grade children were asked to identify fractional parts of sets of objects. Latent class techniques reveal that children applied rules that were adequate for simple problems but had to be replaced to solve more complex problems (Bergan, Towstopiat, Cancelli & Karp, 1982, p. 39).

In a follow-up study to the 1982 work, Bergan, Stone, and Feld (1984) employed a large sample of elementary-age children in their learning of basic numerical skills. Students were presented with tasks that required rules of increasing complexity. The researchers were again studying the replacement of relatively simple rules with more complex extensions of them:

> Hypotheses were generated to reflect the assumption of hierarchical ordering associated with rule replacement. In addition, restrictive knowledge and variable knowledge perspectives were evaluated. Latent-class models were used to test equivalence and ordered relations among the tasks. The results provided evidence that the development of counting skills is an evolving process in which parts of a relatively simple rule are replaced by features that enable the child to perform an increasingly broad range of counting tasks. The results also suggested that rule replacement in counting plays an important role in the development of other math skills. The results also give support for the restrictive knowledge perspective, lending credence to the stair-step learning theory (Bergan, Stone & Feld, 1984, p. 289).

An unusual and indirect, but interesting and suggestive, view of the importance of hierarchies in learning intellectual skills is found in a study by Kallison (1986), who varied sequence (proper vs. manipulated, i.e., reasonable vs. modified to disrupt clarity) and explicitness of lesson organization (organization of lesson explained/organization hidden). In the disrupted sequence treatment, even though care was taken to make an unclear presentation, the hierarchical nature of content relationships was preserved. Four treatments resulted and were used with three ability levels ($2 \times 2 \times 3$). In the study, 67 college students were taught intellectual skills: numeration systems, base 10 and base 5, and how to convert from one system to the other. Although sequence modification did *not* affect achievement substantially, the explicitness of lesson organization explicit did significantly impact achievement, with the more explicit lesson structure promoting better learning. Kallison found no aptitude-treatment interactions.

Kallison was careful to point out that although the sequence was altered, nothing got in the way of learning prerequisites. He modified sequence in such a way that learning hierarchies were not interfered with, only the reasonableness or "clarity" of the lesson organization: Where care was taken *not* to violate learning hierarchy principles, sequence could be disrupted, and it did not impact on learning, even with unclear presentation. As the learning task clearly involves intellectual skills, Gagné's principle of sequencing according to learning hierarchies was not violated. Although there is considerable evidence to validate learning hierarchies already, an unusual confirmation could be obtained by replicating Kallison's study with an additional condition of sequence modified in such a way as to violate learning hierarchy principles but maintain "clarity."

In another unusual test of the validity of the idea that learning tasks can be productively cast in a prerequisite relationship, Yao (1989) sought to test Gagné's assumption that in a validated learning hierarchy, some learners should be able to skip some elements based on their individual abilities. A valid learning hierarchy represents the most probable expectation of greatest learning for an entire sample. In a carefully designed experiment, Yao confirmed that some individuals could successfully skip certain prerequisites, and she found a treatment by ability interaction regarding the pattern of skipping in which certain forms of skipping can be less detrimental for high-ability learners than for low-ability learners. However, as the theory predicts, the treatment that skipped prerequisites was less effective for both low- and high-ability learners (as a group).

18.5.4 Different Learning Outcomes Require Different External Conditions

In an effort to find evidence in support of this basic tenant of the conditions theory, we engaged in a survey of research, looking across a wide scope. The following research is presented in an effort to survey the evidence. The reader may find a dizzying variety of approaches and perspectives reflected. Studies and reviews on the following topics will be briefly presented to illustrate the variety of standpoints from which evidence may be found in general support of the conditions model: interaction between use of objectives and objective type, goal structure and learning task, advance organizers and learning task, presentation mode (e.g., visual presentation) and learning task, evoked cognitive strategies and learning outcomes, expertise and learning hierarchies, teacher thinking for different types of learning, adjunct questions and type of learning, feedback for different types of learning, and provided versus evoked instructional support for different types of learning. What follows, then, is a sample of studies that lend support—in varying ways from varying standpoints—to the theory that different instructional outcomes may best be achieved with differing types of instructional support.

18.5.4.1. Interaction of Use of Objectives and Objective Type. Hartley and Davies (1976) subjected to further examination a review by Duchastel and Merrill (1973) on the effects of providing learners with objectives. Although the original Duchastel and Merrill review found no effect, Hartley and Davies found that "behavioral objectives do not appear to be useful in terms of ultimate posttest scores, in learning tasks calling for knowledge and comprehension. On the other hand, objectives do appear to be more useful in higher-level learning tasks calling for analysis, synthesis, and evaluation" (p. 250). They also note a report by Yellon and Schmidt (1971) which pointed out a possible interference effect from informing students of objectives in problem-solving tasks by reducing the amount of reasoning required.

18.5.4.2. Goal Structure and Learning Task. Johnson and Johnson (1974) found in a review of research on cooperative, competitive, and individualistic goal structures that goal structure interacted with learning task. "Competition may be superior to cooperative or individualistic goal structures when a task is a simple drill activity or when sheet quantity of work is desired on a mechanical or skill-oriented task that requires little if any help from another person" (p. 220). They cite Chapman and Feder, 1917; Clayton, 1964; Clifford, 1971; Hurlock, 1927; Julian and Perry, 1967; Maller, 1929; Miller and Hamblin, 1963; Phillips, 1954; Sorokin, Tranquist, Parten, and Zimmerman, 1930; and Tripplet, 1897. All findings do not clearly distinguish a grouping-by-outcomes (declarative/procedural) condition. For example, Smith, Madden, and Sobel, 1957; Yuker, 1955, found that memorization learning is also enhanced by cooperative work.

On the other hand, Johnson and Johnson pointed out: "When the instructional task is some sort of problem-solving activity, the research clearly indicates that a cooperative goal structure results in higher achievement than does a competitive goal structure" (p. 220). They cite Almack, 1930; Deutsch, 1949a; Edwards, DeVries, and Snyder, 1972; Gurnee, 1968; Husband, 1940; Jones and Vroom, 1964; Laughlin and McGlynn, 1967; O'Connel, 1965; Shaw, 1958; Wodarski, Hamblin, Buckholdt, and Feritor, 1971.

18.5.4.3. Visual Presentation Mode and Learning Task. Dwyer and Parkhurst (1982) present a multifactor analysis (three methods × four outcomes × three ability levels-reading comprehension). This analysis did not concentrate on different types of objectives, but apparently because different contents were used, the authors could draw this conclusion: "The results of this study indicated that (a) different methods of presenting programmed instruction are not equally effective in facilitating student achievement of all types of educational objectives" (p. 108). There were four measures, which were taken to represent four different types of learning outcome: (a) a drawing test involving generation of drawings given labels for parts of the heart such as aorta, pulmonary valve, and so forth; (b) identification test: a multiple-choice test of matching nature on various heart parts; (c) a terminology test consisting of 20 multiple-choice items on knowledge of facts, terms, and definitions; and (d) a comprehension test of 20 multiple-choice items that involved looking at the position of a given heart part during a specified moment in its functioning.

Analysis of the interactions among the different outcomes was not presented in the 1982 study; however, in what appears to be a follow-up study, Dwyer and Dwyer (1987) report the analyses of interactions. The authors conclude that "all levels of depth of processing are not equally effective in facilitating student achievement of different instructional objectives" (Dwyer & Dwyer, 1987, p. 264). In Dwyer's studies, tasks requiring "different levels of processing" appear to these reviewers as generally reflecting differing ways of eliciting declarative knowledge learning, yet meaningful differences among learning tasks were seen and reported by the authors of the studies.

18.5.4.4. Evoked Cognitive Strategies and Learning Outcomes. Kiewra and Benton (1987) report a study that investigated relationships among note taking, review of instructor's notes, and use of higher-order questions and their effect on learning of two sorts: factual and higher order. Subjects were college students in a college class setting. Half of the class was in a condition in which they took notes themselves and reviewed them, and the other half reviewed notes provided by the instructor. At the conclusion of the class, additional practice questions of a "higher-order" nature were provided to half of each group. An interaction between methodology and learning outcomes was reported. "Students who listed and reviewed the instructor's notes achieved more on factual items than did note takers, and . . . higher-order practice questions did not differentially affect test performance" (p. 186).

A study along lines similar to Kiewra and Benton's (1987) study was conducted by Shrager and Mayer (1989), in which some students were instructed to take notes and others were not so instructed, as both groups watched videotaped information. The researchers predicted that the "note taking would result in improved problem-solving transfer and semantic recall but not verbatim recognition or verbatim fact retention for low-knowledge learners, but would have essentially no effects on test performance for high-knowledge learners" (p. 263). This prediction was confirmed, supporting similar findings by Peper and Mayer (1978, 1986), who used the same design but different contents, automotive engines, and statistics. This study is somewhat confounded in treatment and learner characteristics. Degree of declarative knowledge and the stage of transition from declarative to procedural (Anderson, 1990) is often the distinction between novice and expert. Instead of indicating that declarative knowledge and procedural knowledge require different instructional conditions, the study may reveal, instead, that novice learners need more direct and explicit learning guidance in employing cognitive strategies that more knowledgeable learners will do on their own.

There is no doubt that properly applied to the proper task, the mnemonic keyword technique is a powerful one in assisting learning: "The evidence is overwhelming that the use of the keyword method, as applied to recall of vocabulary definitions, greatly facilitates performance. . . . In short, keyword methods effects are pervasive and of impressive magnitude" (Pressley, Levin & Delaney, 1982, pp. 70–71). The strategy, like many others, is a task-specific one: In other words, it makes no sense to apply it to other-than appropriate tasks. Levin (1986) elaborates on this principle and brings to bear an enormous amount of research from him and his associates on particular cognitive strategies (learning strategies) that have considerable power in improving learning.

18.5.4.5. Expertise and Learning Hierarchies. The utility and validity of learning hierarchies within authentic contexts has been studied by Dunn and Taylor (1990) and Dunn and Taylor (1994). In these studies, hierarchical analyses were performed on the activities of language arts teachers (1990) and medical personnel (1994). Development of expertise is encouraged to take place from "task-relevant" experience, assisted by advice strategies developed from hierarchical analysis.

18.5.4.6. Adjunct Questions. Hamilton (1985) provides a review of research on using adjunct questions (see 30.61) and objectives in instruction. The review contains different sections on research with use of adjunct questions with different types of learning, leading to conclusions that vary with type of learning in question.

18.5.4.7. Practice. Some inconsistency is found in the results of studies looking at interaction of practice and types of learning. Hannafin and Colamaio (1987) found a significant interaction between practice and type of learning. Scores on practiced items were higher than nonpracticed items for each type of learning, but the effects were proportionately greatest for factual learning and least influential for procedural learning. However, in a study by Hannafin, Phillips, and Tripp (1986), opposite results were obtained, in which practice was more helpful for factual learning than for application learning. Slee (1989), in a review of interactive video research, noted that a lack of adequacy in lesson materials may confound these studies, as they both used the National Gallery of Art Tour videodisc, which was noted to have insufficient examples and practice available.

Rieber (1988) investigated effects of practice and animations on learning of two types: factual learning and application learning in a CBI lesson. The study looked at both immediate learning and transfer to other learning outcomes. Main-effect differences were not observed between either different elaboration treatments or practice. However, a significant interaction was found between learning outcome and transfer, in which the lesson promoted far transfer for factual information but did not facilitate far transfer for application learning. Another interaction was observed between practice and learning outcome, in which practice improved students application scores more than factual scores. As with studies by Hannafin and associates, unintended attributes of lesson materials may have confounded the study; in this case, as reported by the researcher, the lesson materials may have been too difficult.

18.5.4.8. Feedback for Different Types of Learning. Getsie, Langer, and Glass (1985) provided a meta-analysis of research on feedback (reinforcement versus punishment) and

discrimination learning. They concluded that punishment is an effective form of feedback for discrimination learning: "Punishment is clearly superior to reward only, with effect sizes ranging from .10 to .31" (p. 20). The authors also concluded that reward is the least effective: "First, the most consistent finding is that compared to punishment or reward plus punishment, reward is the least efficient form of feedback during discrimination learning" (p. 20). Although discrimination learning was not compared with other forms of learning, we predict that this conclusion should not be generalized to other forms of learning (e.g., to provide punishment as feedback for practice in learning relational rules, as compared with informative feedback) or to other forms of feedback, such as levels of informational feedback.

Smith and Ragan (1993b) present a compilation of research and practice recommendations on designing instructional feedback for different learning outcomes. Using the Gagné types of learning construct as a framework, they present feedback prescriptions for different categories of learning task. They conclude that "questions regarding the optimal content of feedback . . . really revolve around the issue of the match between the cognitive demands of the learning task; the cognitive skill, prior knowledge, and motivations of the learners; and constraints, such as time, within the learning environment" (p. 100).

An interesting insight into feedback and different types of learning is provided by a meta-analysis of research on feedback by Schimmel (1983). In attempting to explain the major inconsistencies in findings, Schimmel speculated such different characteristics of the instructional content as "different levels of difficulty in recall" (p. 11).

18.5.4.9. Provided vs. Evoked Instructional Support for Different Types of Learning. Husic, Linn, and Sloane (1989) report a study involving effects of different strategies for different types of learning. The content was learning to program in Pascal. Two different college classes were studied, a beginning class in which the learning task was characterized as "learning syntax" (perhaps analogous to rule using) and an advanced class that concentrated on "learning to plan and debug complex problems" (perhaps analogous to problem solving). The abstract of the report showed that:

> Programming proficiency varied as a function of instructional practices and class level. Introductory students benefited from direct instruction, and AP students performed better with less direct guidance and more opportunities for autonomy. Characteristics of effective programming instruction vary depending on the cognitive demands of courses (Husic, Linn & Sloane, 1989, p. 570).

18.6 CONCLUSIONS

There are some conclusions we would draw from this review:

1. It appears that conditions models have a long history of interest in psychology, educational psychology, and instructional technology. This history illustrates work that may not be widely known among instructional technologists today; work that can be instructive as to the actual base and significance of the conditions approach. Perhaps we will see fewer erroneous statements in our literature about what is known regarding types of learning, learning hierarchies, and conditions of learning.

2. There appears to be continuing interest in this area, due to its utility in helping specify instructional strategies and also due to the sizable gaps and inconsistencies that exist in current formulations and research on and with them. We have described in this chapter many fruitful areas for further research.

3. We have reached a conclusion about the work of R. M. Gagné which we would like to share, and suggest that readers examine their own conclusions from reading. We find Gagné's work cast within so much that preceded it and which follows it to remain both dominating in its appeal and utility and, paradoxically, heavily flawed and in need of improvement. The utility and appeal of this work appears to derive greatly from the solid scholarship and cogent writing that Gagné brought to bear, as well as his willingness to change the formulation to keep up with changing times and new knowledge. Many of the gaps and flaws, in keeping with the paradox, appear to be a product of the very changes that he made to keep up with current interests. We believe those changes to be in the main beneficial, but see a clear need for systematic and rigorous scholarship on issues opened by those changes.

4. We still see utility in thinking of learning as more than one kind of thing, especially for practitioners. It is too easy, in the heat of practitioner's struggles, to slip to the assumption that all knowledge is declarative (as is so often seen in the learning outcomes statements of large-scale instructional systems) or all problem solving (as is so often assumed in the pronouncements of pundits and critics of public education), and, as a result, fail to consider either the vast arena of application of declarative knowledge or the multitude of prerequisites for problem solving. It is unhelpful to develop new systems of types of learning for the mere purpose of naming. Improvements in categorization schemes should be based on known differences in cognitive processing and required differences in external conditions.

5. There is substantial weakness in the tie from categories of learning to external conditions of learning. What is missing is the explication of the *internal* conditions involved in acquisition of different kinds of learning. The research on transition from expert to novice and of artificial-intelligence research that attempts to describe knowledge of experts should be particularly fruitful in helping us fill this void. Perhaps this void is a result of failure to have a sufficient emphasis on qualitative research in our field.

6. There is research to support the conclusion that different external events of instruction lead to different kinds of learning, especially looking at the declarative/procedural level. What appears lacking is any systematic body of research directly on the central tenant, not just of conditions models but of practically anyone who would attempt to

teach much less design instruction: What is the relationship between internal learner conditions and subsequent learning from instruction? Such a topic seems a far cry from studies that would directly inform designers as to procedures and techniques, yet such a great deal seems to hinge on that one question. With more insight into it, many quibbles and debates may disappear, and the work of translation into design principles may begin at a new level of efficacy.

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