10 The Elaboration Theory of Instruction

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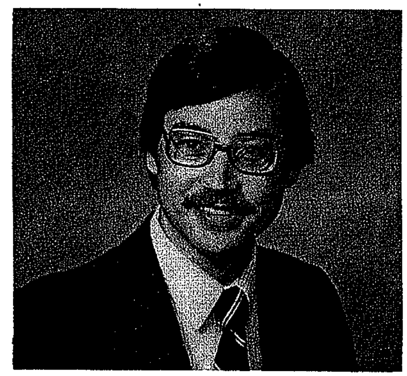

Charles M. Reigeluth

Charles M. Reigeluth received an A.B. in Economics from Harvard University in 1969 and a Ph.D. in Instructional Psychology from Brigham Young University in 1977. He taught science at the high school level for three years before his graduate studies, and after a one-year post-doctorate at Brigham Young, he joined the faculty of the Instructional Design, Development and Evaluation program at Syracuse University in 1978.

Dr. Reigeluth's major professional interest lies in improving public education. Based on the conviction that an educational system should place greater emphasis on well designed resources as the source of knowledge, he has devoted his efforts to contributing to the development of a comprehensive knowledge base to guide the development of such resources, with particular emphasis on computer-based resources. His first major integrative effort was the Elaboration Theory of Instruction, whose initial development was funded by the Navy Personnel R and D Center; and work still continues on the development of the Elaboration Theory. His next major integrative effort was a project to synthesize into a single procedure the state of the art in task analysis methodologies, which play an important role in planning the details of what to teach and the order in which to teach it. This project, funded by the Army's Training and Doctrine Command, resulted in the Extended Task Analysis Procedure (ETAP). Reigeluth's third effort to help integrate existing knowledge into a common knowledge base was this book, which took over two years to prepare. His most recent integrative effort was a project that has enabled him to integrate and extend all of his previous efforts. This project, funded by the Army's Training and Doctrine Command, resulted in the Extended Development Procedure (EDeP). EDeP includes a synthesis of what appears to be the best methods for such diverse forms of instruction as tutoring, lecture, discussion, group activities, individualized resources, and projects, plus a set of criteria for deciding which of these should be used when.

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FOREWORD

The purpose of the Reigeluth–Merrill elaboration theory of instruction is to extend the Component Display Theory (CDT) to the macro level (i.e., to such concerns as selection, sequencing synthesizing, and systematic review of related ideas). In other words, its purpose is to integrate as much as possible of our current knowledge about learning and instruction on the macro level. Like CDT, it only deals with the cognitive domain; but unlike CDT, it already includes many motivational-strategy components, and work is currently underway to integrate more of Keller's work with the elaboration theory.

The elaboration theory's prescriptions are based both on an analysis of the structure of knowledge and on an understanding of cognitive processes and learning theories. As with other theories, goals form the basis for prescribing models. The most important aspect of all three models is a specific kind of simple-to-complex sequence, which is an extension of Ausubel's *subsumptive sequencing*, Bruner's *spiral curriculum*, and Norman's *web learning*. This sequencing pattern helps to build stable cognitive structures, provides a meaningful context for all instructional content, and provides meaningful application-level learning from the very first "lesson." Gagné's learning-prerequisite sequences are then introduced only as they become necessary within each lesson, and systematic integration and review are provided at the end of each lesson and unit. Also, each lesson is adjusted in certain ways to make it appropriate for the ability level of the students in relation to the complexity or difficulty of the content.

Like CDT, the Elaboration Theory organizes instruction in such a way as to facilitate learner control; but on the macro level this means control over selection and sequencing of ideas as well as control over frequency and timing of such strategy components as synthesizers and reviews. Simple-to-complex sequencing allows the learner to make an informed decision as to what ideas interest him or her the most and hence warrant "zooming in" for more detail about those ideas. The use of analogies is another important feature of the elaboration theory.

Although much work remains to be done to develop the Elaboration Theory to its full potential, it (like CDT) is indicative of the integrative, multiperspectived approach to model building and theory construction that is sorely needed at this point in the evolution of the discipline. Particularly useful right now would be some extensive research and field tests.

C. M. R.

The Elaboration Theory of Instruction

INTRODUCTION

Context: Scope and Limitations of the Elaboration Theory

The field of instructional science is concerned with understanding and improving methods of instruction so as to make them more effective, more efficient, and more appealing. In Chapter 1 of this book, a distinction is made between the micro level (which deals only with methods for teaching a single idea, such as the use of examples of that idea) and the macro level (which deals only with methods that relate to several ideas, such as sequencing those ideas). The Elaboration Theory is exclusively on the *macro* level—it prescribes methods that deal with many related ideas, such as how to sequence them. (The preceding chapter in this book presents a compatible theory that deals only with the micro level.) Chapter 1 also describes three major kinds of instructional methods: organizational, delivery, and management. The Elaboration Theory makes no attempt to deal with either delivery or management strategies, although these are important variables that need to be integrated into any instructional model or theory if it is to be sufficiently comprehensive to be optimally useful to instructional developers and planners.

The Elaboration Theory thus deals only with organizational strategies at the macro level. The macro level is made up mainly of four problem areas. We have referred to these as the *four S's*: selection, sequencing, synthesizing, and summarizing of subject-matter content. The Elaboration Theory attempts to prescribe optimal methods in all four of these areas.

The Elaboration Theory of instruction prescribes that the instruction start with a special kind of overview that teaches a few general, simple, and fundamental (but not abstract) ideas. The remainder of the instruction presents progressively more detailed ideas, which elaborate on earlier ones. The theory also prescribes the use of prerequisite sequences within parts of the simple-to-complex sequence, and it prescribes the systematic use of review and synthesis, among other things (see section on "Strategy Components" later).

History: Origins and Precursors

During the past 10 or 15 years, considerable new knowledge has been generated about isolated aspects of macro strategies. Robert Gagné (1968, 1977) identified an important kind of relationship in subject matter: the *learning prerequisite* (see Chapter 4, this volume). The concept of a learning prerequisite involves the fact that some knowledge must be acquired before other knowledge can be acquired. One must understand the concept "volume" before one can understand the principle that describes the relationship between volume, pressure, and temperature. A complete set of learning prerequisites for a given idea comprises what is called a *learning hierarchy* (see Chapter 4). This has given rise to the hierarchical approach to task analysis. Various theorists have more complex methodologies for conducting more precise and thorough hierarchical task analyses (see, for example, the review by Bergan, 1980), but such complexity and precision is of questionable utility to instructional developers.

However, the learning prerequisite is only one important kind of relationship to guide instructional design. Another important one is represented by the information-processing approach to task analysis. This *procedural* type of relationship describes the order in which tasks must be performed, as opposed to the order in which they must be learned. One can *learn* how to do the last step in a procedure first, but one cannot *do* the last step first in a performance of that complete procedure. Gropper (1974), Landa (1974), P. Merrill (1971), Resnick (1973), and Scandura (1973) were among the first to emphasize the importance of this kind of relationship for instructional design on the macro level. For an excellent review of task-analysis methodologies, see Resnick (1976).

David Ausubel (1963, 1968) pioneered some important knowledge about kinds of *instructional sequences* that help instructional content to be more meaningful for a learner and that thereby help the instruction to result in better learning and retention. He advocated initiating instruction with general-level knowledge that "subsumes" the content that is to follow; the remainder of the instruction is then a process of *successive differentiation*—the gradual introduction of more detailed and specific knowledge about the general-level ideas. This is similar to (although much more highly developed than) Bruner's (1960) notion of a *spiral curriculum*. Recent developments under the rubric of *schema theory* (Anderson, Spiro, & Montague, 1977; Collins & Quillian, 1970; Lindsay & Norman, 1977; Rumelhart & Ortony, 1977) have reinforced and supported the general-to-detailed sequencing advocated by Ausubel. In fact, Norman's (1973) notion of *web learning* is similar to the spiral curriculum and successive differentiation patterns of sequencing instruction.

These isolated advances in our knowledge about methods of instruction on the macro level (i.e., hierarchical, information-processing, and cognitive-elaboration approaches to sequencing) have often appeared to compete with and even (in a superficial sense) occasionally contradict each other. But they each accurately and truthfully describe different aspects of the structure of knowledge, the process of learning, and/or the process of instruction. Therefore, the purpose in developing the Elaboration Theory was to create a comprehensive set of macro-level models that would integrate all of this recent knowledge in a way that would greatly improve our ability to design good instruction. In the process of doing this, it was sometimes necessary to attempt to fill in gaps that became apparent in our knowledge about instruction at the macro level.

Organization of This Chapter

The Elaboratory Theory is comprised of: (1) three *models* of instruction; and (2) a *system for prescribing* those models on the basis of the goals for a whole course of instruction.* Like all models of instruction, each of these three models is made up of *strategy components*. It is important to understand that the Elaboration Theory is by no means static; rather, it continues to develop and improve as research reveals weak strategy components that should be eliminated from the models and new strategy components that should be integrated into the models.

The following are the major sections of this chapter:

1. An *analogy* that helps to give a general idea of what the Elaboration Theory is.
2. A description of each individual *strategy component*.
3. A description of the *general model* (i.e., the common features of the three models that comprise the Elaboration Theory).
4. A description of the ways in which the *three models* differ from each other and the system for *prescribing* when each model should be used.
5. A summary of some *procedures for using* the elaboration model in the development or evaluation of instruction.
6. Some support for the *validity* of the Elaboration Theory.

AN ANALOGY

A good introduction to the nature of the Elaboration Theory of instruction is an analogy with a zoom lens. Studying a subject matter "through" the elaboration model is similar in many respects to studying a picture through a zoom lens on a movie camera. A person starts with a wide-angle view, which allows him or her to see the major parts of the picture and the major relationships among those parts (e.g., the composition or balance of the picture), but without any detail.

The person then zooms in on a part of the picture. Assume that, instead of being continuous, the zoom operates in steps or discrete levels. Zooming in one level on a given part of the picture allows the person to see more about each of the major subparts. After having studied those subparts and their interrelationships, the person could then zoom back out to the wide-angle view to review the other parts of the whole picture and to review the context of this part within the whole picture.

The person continues this pattern of zooming in one level (or one additional level) to see the major subparts of a part and zooming back out for context and

*Editor's note: This pattern should be quite familiar by now!

review. The person could be forced to complete all of one level before proceeding to the next level. Or the person could be forced to go to the full depth of detail (to zoom in as far as the camera will go) on one part before proceeding to another part of the picture. Or the person could be allowed to choose to follow his or her own interests in viewing the picture, in which case the person can make an informed decision (on the basis of information from the wide-angle view) as to what part of the picture would interest him or her the most. The only restriction is that the person may not view any part of the picture unless he or she has already viewed it from the next higher (wider-angled) level.

In a similar way, the Elaboratory Theory of instruction starts the instruction with a special kind of *overview* of the simplest and most fundamental ideas within the subject matter; it adds a certain amount of *complexity* or *detail* to one part or apsect of the overview; it *reviews* the overview and shows the *relationships* between the most recent ideas and the ideas presented earlier; and it continues this pattern of elaboration followed by summary and synthesis until the desired level of complexity has been reached on all desired parts or aspects of the subject matter. It also allows for informed learner control over the selection and sequencing of content.

Of course, it must be remembered that the zoom-lens analogy is just an analogy and therefore that it has nonanalogous aspects. One such dissimilarity is that all the detail of the picture is actually present (although usually not noticed) in the wide-angle view, whereas the complexity is not there at all in the overview.

Now, some people, ask, "Don't you have to go through a lot of learning prerequisites (Gagné, 1968) to teach the overview?" The answer is a definite "No." In fact, like Bruner's (1960) *spiral curriculum,* few unmastered learning prerequisites (if any) exist at the level of the overview. As learners work to deeper levels of complexity, increasingly complex prerequisites exist, but many of them will already have been taught as parts of previous lessons. Hence, if prerequisites are held back until the lesson for which they are immediately necessary, there will be only a few prerequisites for a lesson at any level of complexity, and the learners will want to learn those prerequisites because they will see their importance for learning at the level of complexity that now interests them.

Use of the Elaboration Approach

The simple-to-complex sequence prescribed by the Elaboration Theory helps to ensure that the learner is always aware of the context and importance of the different ideas that are being taught. It allows the learner to learn at the level of complexity that is most appropriate and meaningful to him or her at any given state in the development of one's knowledge. And the learner never has to struggle through a series of learning prerequisites that are on too deep a level of complexity to be interesting or meaningful at the initial stages of instruction.

Unfortunately, a zoom-lens approach has not been widely used in instruction, in spite of its fundamental simplicity and intuitive rationale. Many textbooks begin with the "lens" zoomed in to the level of complexity deemed appropriate for the intended student population; and they proceed—with the "lens" locked on that level of complexity—to pan across the entire subject matter. This has unfortunate consequences for synthesis, retention, and motivation. Using a hierarchical approach, many instructional developers have used a sequence that in some ways resembles beginning with the lens zoomed all the way in and proceeding in a highly fragmented manner to pan across a small part and zoom out a bit on that part, pan across another small part and zoom out a bit, and so on, until the whole scene has been covered and, to some limited degree, has been integrated by the very end of the instruction. This has also had unfortunate consequences for synthesis, retention, and motivation. And some educators have intuitively groped for an elaboration-type approach with no guidelines on how to do it. This has resulted in a good deal less effectiveness than is possible for maximizing synthesis, retention, and motivation.

The major reason for the lack of utilization of an elaboration approach in instruction is probably that the hierarchical approach has been well-articulated and is a natural outgrowth of a strong behavioral orientation in educational psychology, which was very much in vogue until recently. This in effect put "blinders" on most of the few people who have been working on instructional-design strategies and methodology.

The Elaboration Theory does not reject the hierarchical approach; in point of fact, an idea cannot be learned before its true learning prerequisites have been learned. Rather the Elaboration Theory integrates hierarchical sequencing within the overall structure of an elaborative sequence. As an approach that attempts to integrate the best strategies of a wide variety of researchers and theoretical perspectives, the Elaboration Theory prescribes the use of a number of major strategy components, including learning prerequisite sequencing, at various points during the instruction.

STRATEGY COMPONENTS

The Elaboration Theory presently utilizes seven major strategy components: (1) a special type of simple-to-complex sequence (for the main structure of the course); (2) learning-prerequisite sequences (within individual lessons of the course); (3) summarizers; (4) synthesizers; (5) analogies; (6) cognitive-strategy activators; and (7) a learner-control format. These components are described briefly here.

1. An Elaborative Sequence

An elaborative sequence is a special kind of *simple-to-complex sequence*. But there are many different ways to form a simple-to-complex sequence for a single course, and naturally some of them are better than others. For example, one could start a history course by summarizing the major events in history, then proceed to provide a little more detail about each of those events and to add a few of the next most important events, and so on, until the desired level of detail is reached for that course. The use of such things as overviews (Hartley & Davies, 1976), advance organizers (Ausubel, 1968), web learning (Norman, 1973), and the spiral curriculum (Bruner, 1960) are all attempts to use a simple-to-complex sequence to some degree. The Elaboration Theory proposes that an *elaborative sequence* (of which there are three kinds) is the best for reasons that are outlined here, but further research is needed to adequately test this hypothesis.

An *elaborative sequence* is a simple-to-complex sequence in which: (1) the general ideas *epitomize* rather than summarize the ideas that follow; and (2) the epitomizing is done on the basis of a *single type of content.*

Epitomizing versus Summarizing

Epitomizing differs from summarizing in two important ways. It entails: (1) presenting a very *small number* of the ideas that are to be taught in the course; and (2) presenting them at a concrete, meaningful, *application level.* On the other hand, summarizing usually entails presenting a considerably larger number of the ideas but at a more superficial, abstract, memorization level. For example, a summary of an introductory course in economics might present a label for, or even a statement of, each of the most important principles of economics, whereas an *epitome* of that course would teach the one or two most fundamental and simple principles (such as the law of supply and demand) at the application level. The application level is what Merrill refers to in Chapter 9 as the *use a generality* level, and in this case it means that the student would be able to use each of those principles to predict or explain novel cases. To epitomize is not to lightly preview all of the important course content; rather it is to teach (on an application level, complete with examples and practice that enable the learner to relate it to previous knowledge and experience) a *few fundamental and representative ideas* that convey the essence of the entire content. Those ideas are chosen such that all the remaining course content provides more detail or more complex knowledge about them.

Single Type of Content

With respect to a single type of content, the process of epitomizing is done with just one of three types of content: concepts, procedures, or principles. A *concept* is a set of objects, events, or symbols that have certain characteristics in common. Knowing a concept entails being able to identify, recognize, classify, or describe what something is. For example, "sonnet" is a concept. A *procedure* is a set of actions that are intended to achieve an end. It is often referred to as a skill, a technique, or a method. Knowing a procedure entails knowing how to do something. For example, "the steps for critically analyzing a sonnet" are a procedure. A *principle* is a change relationship; it indicates the relationship between a change in one thing and a change in something else. It may also be called a hypothesis, a proposition, a rule, or a law, depending on the amount of evidence for its truthfulness. Usually, it describes causes or effects, either by identifying what will happen as a result of a given change (the effect) or why something happens (the cause). For example, "including an introduction in a written composition will result in a more effective communication" is a principle.*

One of these three types of content—concept, procedure, or principle—is chosen as the most important type for achieving the general goals of the course. Henceforth the elaboration sequence is characterized as having a *conceptual organization*, a *procedural organization*, or a *theoretical organization*, in which the respective type of content (which is called the *organizing content*) is epitomized at the beginning of the course and is gradually elaborated on throughout the remainder of the course, in such a way that most lessons not only elaborate on a previous lesson but also epitomize several later lessons. The other two types of content and rote facts (which are all called the *supporting content*) also appear throughout the length of the course, but they are only introduced when they are highly relevant to the particular organizing content ideas that are being presented at each point in the course sequence.

In essence the process of epitomizing entails: (1) selecting one type of content as the organizing content (concepts, principles, or procedures); (2) listing all of the organizing content that is to be taught in the course; (3) selecting a few organizing content ideas that are the most basic, simple, and/or fundamental; and (4) presenting those ideas at the application level rather than the more superficial and abstract memorization level. Detailed procedures have been developed to guide instructional developers, and they are summarized later in this chapter.

General versus Simple versus Abstract

Because the terms *general, simple,* and *abstract* are often confused, we discuss them here. These terms are parts of three different continua: (1) general to detailed; (2) simple-to-complex; and (3) abstract to concrete (Reigeluth, 1979a). These three continua are illustrated in Fig. 10.1. The first two are very similar to each other, but the third is very different.

The *general-to-detailed* continuum refers primarily to a continuum formed by subdividing ideas (either concepts or procedures) or by lumping ideas (subordinate concepts or subprocedures) together. *General* has breadth and inclusiveness (i.e., lots of things lumped together), whereas *detailed* is usually narrow (subdivisions). In Fig. 10.1(a), "polar bear" is a more detailed concept than "animal"; it requires finer discriminations (polar bears are more similar to other kinds of bears than animals are to nonanimals) and has fewer examples (there are fewer polar bears than there are animals). Since general concepts entail fewer and grosser discriminations, they are also simpler than detailed concepts.

*Editor's note: See Chapter 1, p. 14, for more about principles.

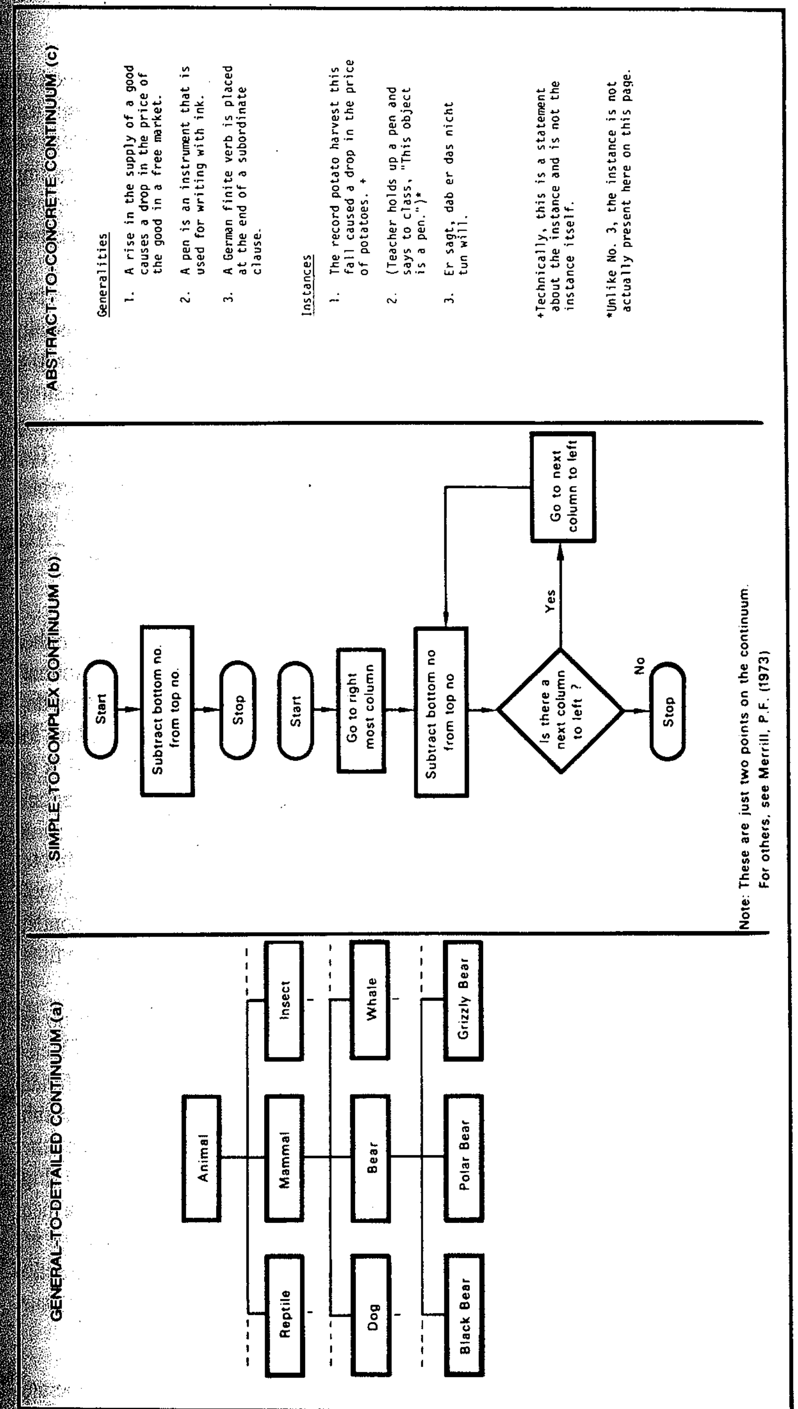


FIG. 10.1 Illustrations of three continua that are often confused.

The *simple-to-complex* continuum refers primarily to a continuum formed by adding or removing parts of ideas (either principles or procedures). "Simple" has few parts, whereas "complex" has many parts. In Fig. 10.1(b), the procedure for subtracting multidigit numbers is more complex than the procedure for subtracting single-digit numbers. Additional complexity can be added by introducing sub-procedures for "borrowing" when the top number is smaller than the bottom number.

The *abstract-to-concrete* continuum refers to tangibility, and there are two major types of tangibility. First, *generalities* are abstract, and instances are usually concrete: The definition of a tree is not tangible, but a specific tree (an object) is tangible. This is the most important abstract-to-concrete continuum for instructional theory. Second, some concepts are considered abstract because their instances are not tangible. "Intelligence" is a good example of an abstract concept. This second abstract-to-concrete continuum is largely irrelevant for our present purposes, although it does have some important implications as to what would be an optimal model for teaching different kinds of concepts.

The Epitome

On the basis of these distinctions, epitomizing always entails identifying either very *general* or very *simple* ideas, but *not abstract* ones. The concept "animal" is no more abstract than the concept "polar bear," the procedure for subtracting whole numbers without borrowing is no more abstract than the procedure for subtracting fractions with borrowing, and the law of supply and demand is no more abstract than the principle of utility maximization. Epitomizing also entails teaching the epitomized content at the application level—that is, with some concrete examples and practice, as well as with an abstract generality. (See Chapter 9 for more information about application-level instruction.) In essence the elaboration theory's "special kind of overview" epitomizes a single kind of content (although it also includes the other kinds of content that are highly related to those epitomized ideas).

Because the process of epitomizing yields a special kind of overview, we do not call it an overview—we call it an *epitome*. The content for an epitome is selected by: (1) epitomizing the organizing content to a small number of the most fundamental, representative, general, and/or simple ideas (i.e., the ideas that best subsume the rest of the organizing content); and (2) including whatever of the other types of content that are highly relevant (including learning prerequisities). Fig. 10.2 shows the content for a conceptual epitome, a procedural epitome, and a theoretical epitome. Contrary to our earlier prescriptions, preliminary indications are that an epitome ought to contain about 10 hours of instruction, including practice exercises (Pratt, 1982; Reigeluth, 1982), but more research is needed on this issue.

Levels of Elaboration

In the zoom-lens analogy we mentioned that the zooming-in process operates in steps or levels. Each level provides more detail or complexity about something in the preceding level. Hence, the *first level* of elaboration elaborates on the

Content for a Conceptual Epitome for an Introductory Course in Statistics

1. Organizing content (concepts)
   Kinds of measures
   a. Elevation (or central tendency)
   b. Spread
   c. Proportion
   d. Relationship
   Kinds of methods
   a. Description
   b. Estimation
   c. Hypothesis testing
2. Supporting content
   (Learning prerequisites for the aforementioned concepts)

Practically all concepts in statistics can be viewed as elaboration on these concepts, through development of parts or kinds conceptual structures.

Content for a Theoretical Epitome for an Introductory Course in Economics

1. Organizing content (principles)
   The law of supply and demand
   a. An increase in price causes an increase in the quantity supplied and a decrease in the quantity demanded.
   b. A decrease in price causes a decrease in the quantity supplied and an increase in the quantity demanded.
2. Supporting content
   The concepts of
   a. Price
   b. Quantity supplied
   c. Quantity demanded
   d. Increase
   e. Decrease

Practically all principles of economics can be viewed as elaborations on the law of supply and demand, including those that relate to monopoly, regulation, price fixing, and planned economies.

Content for a Procedural Epitome for an Introductory Course in Literature

1. Organizing content (procedures)
   There are four major steps in the multidimensional analysis and interpretation of creative literature.
   a. Identifying elements of the dramatic framework--character and plot.
   b. Combining the elements into composites appropriate for analysis of their literal meaning--analysis of character in terms of plot.
   c. Figuratively interpreting the elements--symbolism through character, mood, tone.
   d. Making a judgement of worth--personal relevance, universality.

FIG. 10.2 (continued)

(This procedure is simplified by introducing only <u>two</u> elements for the analyses in a and b, <u>three</u> in c, and <u>two</u> in d. It is further simplified by introducing <u>only</u> those procedures and concepts necessary for the analysis and interpretation of a <u>short poem</u>. Complexity is later added by increasing the number of elements used in each stage of analysis or interpretation and by introducing procedures and concepts needed for analyzing and interpreting more complicated types of creative literature.)

2. Supporting content
   Concepts necessary for performing the procedure in 1.
   - a. Character
   - b. Plot
   - c. Symbolism
   - d. Mood
   - e. Tone
   - f. Universality

Practically all procedures for analyzing and interpreting creative literature can be viewed as elaborations on these four steps.

FIG. 10.2 **The instructional content for a conceptual epitome, a procedural epitome, and a theoretical epitome.**

organizing content presented in the epitome; the *second level* elaborates on the organizing content presented in the first level, and so on. A lesson on the first level is in effect an epitome of all those lessons on the second level that elaborate on it. Figure 10.3 shows a partial example of a level-1 lesson by showing some organizing content that elaborates on the conceptual epitome in Fig. 10.2, some organizing content that elaborates on the procedure epitome in Fig. 10.2, and some organizing content that elaborates on the theoretical epitome in Fig. 10.2. The most important supporting content is also listed.

To give a clearer idea of what each of the three types of elaborative sequences—conceptual, procedural, and theoretical—is like, it is necessary to understand a little about the structure of knowledge. A *knowledge structure* is something that shows relationships among pieces of knowledge (i.e., among facts, concepts, principles, and procedures). The elaboration theory proposes that there are four major types of relationships that are important for purposes of instruction: conceptual relationships, procedural relationships, theoretical relationships, and learning-prerequisite relationships (Reigeluth, Merrill, & Bunderson, 1978; Reigeluth, Merrill, Wilson, & Spiller, 1980). The first three kinds of relationships are described next, and learning-prerequisite relationships are described later under strategy component 2, *A Learning Prerequisite Sequence.*

A *conceptual structure* shows superordinate/coordinate/subordinate relationships among ideas. There are three important types of conceptual structures: *parts* conceptual structures, which show concepts that are components of a given concept; *kinds* conceptual structures, which show concepts that are varieties or types of a given concept; and *matrices* or tables, which are combinations of two or more conceptual structures. Figs. 10.4, 10.5, and 10.6 show examples of each kind of conceptual structure.

<u>Content for an Elaboration on the Conceptual Epitome</u>

1. Organizing content (concepts)
   Kinds of measures

a.1 Mean	a.2 Median	a.3 Mode
b.1 Variance	b.2 Standard deviation	
c.1 Percent	c.2 Decimal	c.3 Fraction
d.1 r_s	d.2 r_{pb}	d.3 r_{ϕ}

2. Supporting content
   (Learning prerequisites for the aforementioned concepts)
   Additional elaborations would define kinds of methods for each kind of measure (e.g., methods of hypothesis testing for spread).

<u>Content for an Elaboration on the Theoretical Epitome</u>

1. Organizing content (principles)
   - a. Effects of changes in supply schedules on equilibrium price.
   - b. Effects of changes in demand schedules on equilibrium price.
   - c. The principle of why changes occur in supply schedules or demand schedules.
2. Supporting content
   - a. The concepts of supply, supply schedule, and supply curve.
   - b. The concepts of demand, demand schedule, and demand curve.
   - c. The concept of changes in supply schedules or demand schedules.
   - d. The concept of equilibrium price.

   Beyond this point, elaborations would split into those that elaborate on the supply side (i.e., production and costs) and those that elaborate on the demand side (i.e., consumption and utility).

<u>Content for an Elaboration on the Procedural Epitome</u>

1. Organizing content* (procedures)
   - a. Procedures for identifying the remaining elements of the dramatic framework: setting, perspective, and language
   - b. Procedures for combining elements into appropriate composites for analysis of literal meaning:
     - -Character, plot, and setting
     - -Perspective, character, and plot
     - -Language
2. Supporting content:
   - a. Concepts: setting, perspective, language, imagery
   - b. Procedure: the analysis of patterns of imagery

*This organizing content elaborates only on steps a and b (which must be elaborated simultaneously because of their interrelatedness). The elaboration involves the addition of elements that must be identified (stage a) and analyzed in combination (stage b).

FIG. 10.3 **The instructional content for level-1 elaborations on the conceptual, theoretical, and procedural epitome in FIG. 10.2.**

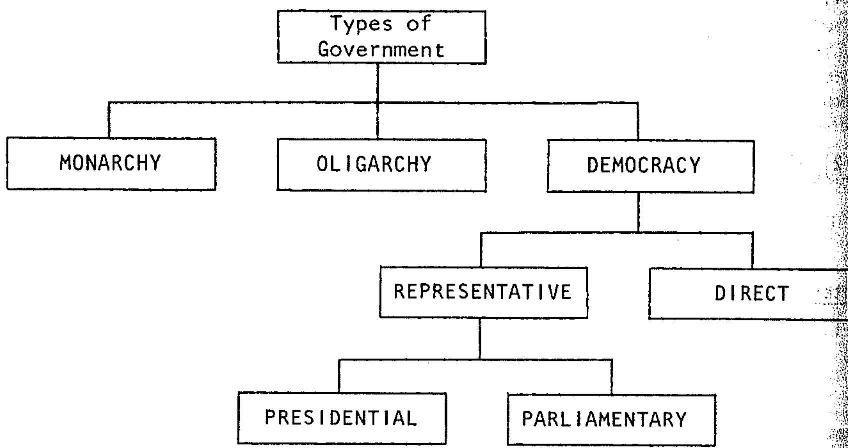


FIG. 10.4 An example of a kinds conceptual structure.

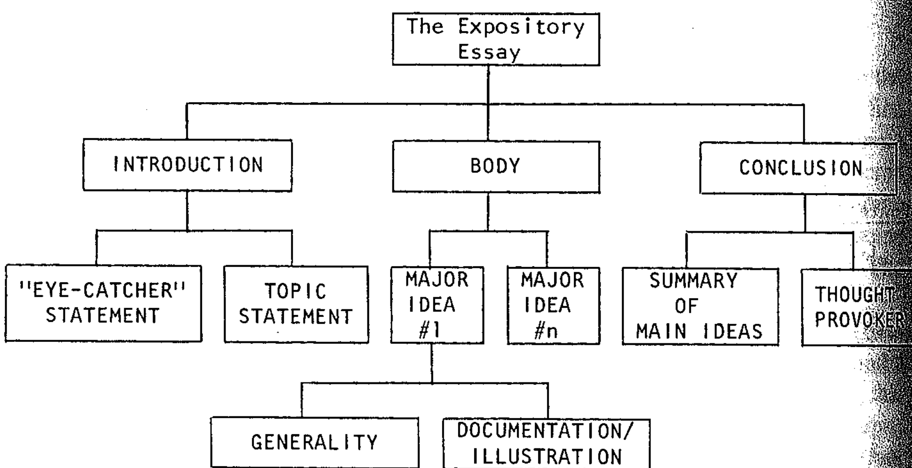


FIG. 10.5 An example of a parts conceptual structure.

A *procedural structure* shows relationships among steps of a procedure. There are two important kinds of procedural relationships: *procedural-order* relationships, which specify the order(s) for performing the steps of a procedure; and *procedural-decision* relationships, which describe the factors necessary for deciding which alternative procedure or subprocedure to use in a given situation. Figure 10.7 and Fig. 10.8 show examples of each kind of procedural structure.

A *theoretical structure,* or theoretical model, shows change relationships among events. There are two major kinds of theoretical structures. The most common kind of theoretical structure is one that describes *natural* phenomena—that is, it is a branching chain of interrelated *descriptive* principles. The other important kind describes phenomena that optimize (or sometimes merely influence) some desired outcome—that is, it is a branching chain of interrelated *prescriptive* principles. Usually it will merely identify the desired outcome(s) (e.g., as a heading), and then prescribe the "causes" in a way that shows how they should all be interrelated. Theoretical structures can be arranged on a continuum from purely descriptive to purely prescriptive, in which case a purely prescriptive theoretical structure (or model) is very similar to a procedural-order structure. Figure 10.9 and Fig. 10.10 show examples of each.

	REPTILES	MAMMALS	BIRDS	FISH	INSECTS
HERBIVORES	TURTLES ...	COWS ...	CHICKADEES ...	MINNOWS ...	ANTS ...
CARNIVORES	SNAKES ...	LIONS ...	VULTURES ...	SHARKS ...	LADY BUGS ...
OMNIVORES	LEOPARD LIZARDS ...	DOGS ...	ROBINS ...	CARP ...	BLACK STINK BUGS ...

FIG. 10.6 A portion of a matrix structure (or table) combining two kinds conceptual structures.
KEY: In this matrix, each box is a kind of both its row heading and its column heading.

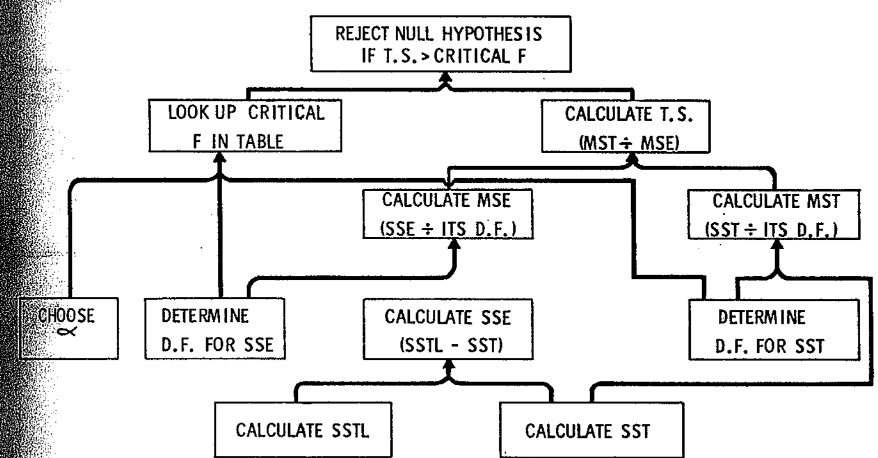


FIG. 10.7 An example of a procedural-order structure.
KEY: The arrow between two boxes on different levels means that the lower box must be performed before the higher box can be performed.

EB FLOW CHART FOR MATCHED PAIRS

SELECTION CRITERIA

For two independent samples see page 302.

Relatively powerful methods which can be used to demonstrate a difference in elevation in various limited senses

- Parametric tests on means. These tests are equivalent to each other. They apply also to medians if both distributions are assumed symmetric. p. 251
  - Have $M_1, M_2, S_1, S_2, r_{12}$ already been computed?
    - No:
      - Better-known method
      - Quicker method
    - Yes
- Nonparametric tests of the null hypothesis that difference scores are distributed symmetrically around zero. (Remember symmetry does not imply normality.) pp. 274, 349, 251
  - Powerful, fairly quick test
  - Very quick test with lower power than any above
- A nonparametric test on medians. This test applies also to means if both distributions are assumed symmetric.

p. 296

A method with power comparable to EB10 which can demonstrate a range of complete dominance p. 296

FIG. 10.8 (continued)

METHODS

EB7★★★ t TEST FOR MATCHED PAIRS
Compute $D = X_1 - X_2$ for each person.
$$t = \frac{M_D}{S_D/\sqrt{N}} \qquad df = N - 1$$
M_D, S_D are the mean and standard deviation of D's p. 344

EB7a★ SANDLER A, MODIFIED
Compute $D = X_1 - X_2$ for each person.
$$A' = \frac{(\Sigma D)^2}{\Sigma D^2}$$
p. 345

EB7b★★★ t TEST FOR MATCHED DATA USING INTERMEDIATE STATISTICS
$$t = \frac{M_1 - M_2}{\sqrt{\dfrac{S_1^2 + S_2^2 - 2r_{12}S_1S_2}{N}}} \qquad df = N - 1$$
p. 347

EB8★★ WILCOXON SIGNED-RANKS TEST FOR MATCHED PAIRS
For each person compute $D = X_1 - X_2$. Then use Method **EA4** (p. 286) to test the null hypothesis $\mu_D = 0$. p. 348

EB9★★ SIGN TEST FOR MATCHED PAIRS
Count the number of matched pairs for which $X_1 > X_2$, and the number for which $X_1 < X_2$. Redefine N as the sum of these two numbers, thus ignoring pairs for which $X_1 = X_2$. Enter the two numbers counted into Method **PA1** (p. 436) or Method **PA2** (p. 437). p. 349

EB10★★ SIGN TEST FOR PERCENTILE SCORES
Divide the scale at some point P; no score in either group should exactly equal P. Count the number of pairs for which $X_1 < P$ and $X_2 > P$. Count the number of pairs for which $X_1 > P$ and $X_2 < P$. Redefine N as the sum of these two numbers. Enter the two numbers into Method **PA1** (p. 436) or **PA2** (p. 437). p. 350

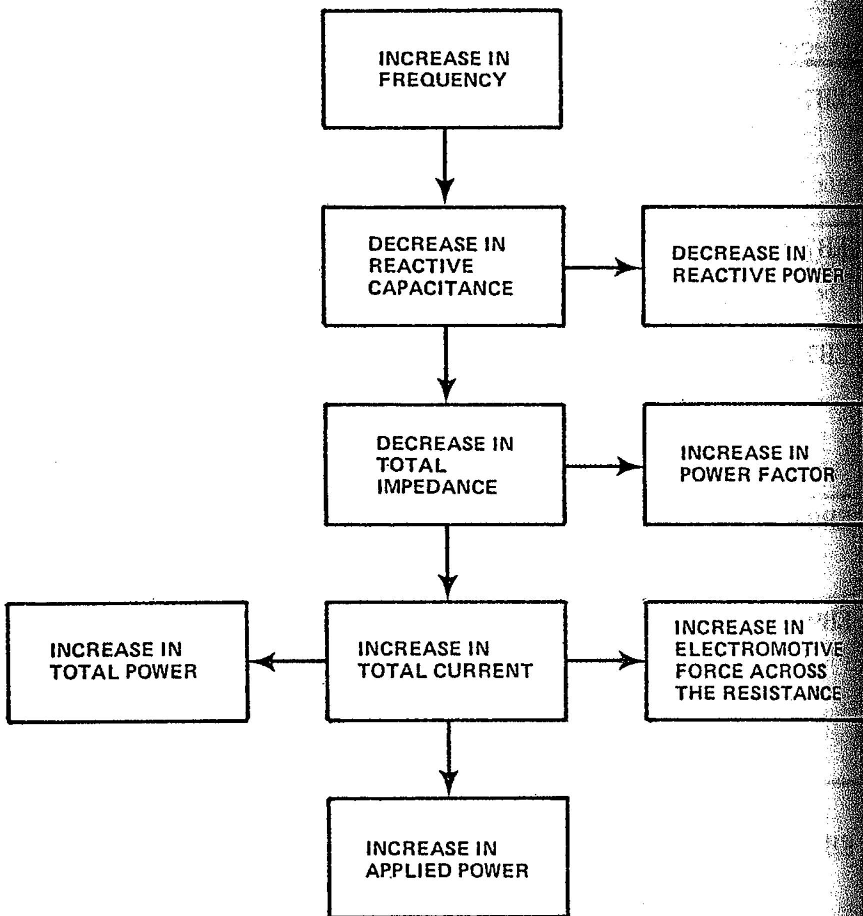
EB11★ SIGN TEST FOR EACH POINT ON AN OD CURVE
See Method Outline p. 351

FIG. 10.8 An example of a procedural-decision structure.

More About Epitomizing

Considering these three major kinds of knowledge structures, we can now elaborate a bit on the nature of the three types of elaborative sequences and how each differs from a summarizing approach to simple-to-complex sequencing.

Procedural content can be sequenced in any of five major ways: (1) forward chaining, which occurs at a single level of complexity and entails teaching all the steps in the order in which they are performed; (2) backward chaining, which also occurs at a single level of complexity but entails teaching all the steps in the opposite of the order in which they are performed; (3) a hierarchical sequence, which entails teaching all possible substeps (parts) of a step before integrating them, then doing the same for another step, and so on, until all parts have finally been taught and integrated; (4) a general-to-detailed sequence based on summarizing, which



Key: The arrow between two boxes means that the change in one box causes the change in the other box to occur.

FIG. 10.9 An example of a descriptive theoretical structure.

entails something like presenting a general-level flow chart or list of all steps (or clusters of steps) at the very beginning of the instruction, followed by elaborating them down to the application level; and (5) a simple-to-complex sequence based on epitomizing, which entails presenting the shortest path (or shortest procedure) at the application level at the very beginning of the instruction, following by elaborating it out to the desired breadth and complexity of alternative paths (or procedures), each additional path usually being progressively more complex. These last two methods respectively entail: (1) abstract breadth followed by elaborating down to the application level; and (2) narrow application followed by elaborating out to the required breadth and complexity of paths (or procedures).

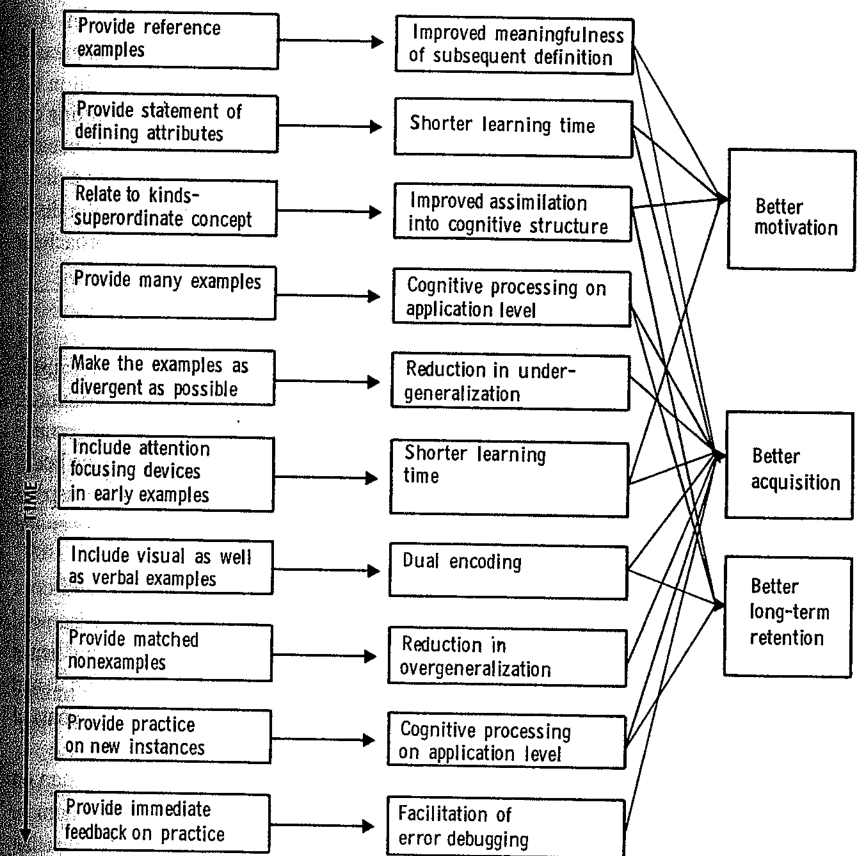


FIG. 10.10 An example of a prescriptive-theoretical structure.

KEY: Each arrow means "causes."
NOTE: In the extreme, the prescriptive-theoretical structure is practically identical to a procedural-order structure, in that the middle and right-hand columns of boxes drop out (or more precisely, are incorporated into a statement of the goals and conditions that provide the basis for prescribing it).

In the case of *concepts*, the summarizing approach is also one of *abstract breadth*: It is a sequence in which all of the important concepts are listed in the overview, followed by elaborating each down to the application level. And the epitomizing approach is also one of *narrow application*: It is a sequence in which only a few (the most general and inclusive) concepts are taught in the overview, but they are taught at the application level, followed by elaborating out to the remaining concepts (which are configured as being "down" on a conceptual structure because they are more detailed and less inclusive).

Finally, in the case of *principles*, the summarizing approach is also one of *abstract breadth*: It is a sequence in which all of the important principles are listed in the overview, followed by elaborating each down to the application level. And the epitomizing approach is still one of *narrow application*: It is a sequence in which only a few (the most simple and fundamental) principles are taught in the overview, but they are taught at the application level, followed by elaborating out to the remaining principles. As it turns out, this sequence of principles is usually very similar to the sequence in which those principles were discovered in a discipline, in which case those texts that follow the historical development of a discipline (such as some science texts) come quite close to an epitomizing approach for theoretical content.

Rationale

A simple-to-complex sequence is prescribed by the elaboration theory because it is hypothesized to result in: (1) the formation of more stable cognitive structures, hence causing better long-term retention and transfer; (2) the creation of meaningful contexts within which all instructional content is acquired, hence causing better motivation,* and (3) the provision of general knowledge about the major aspects of the instructional content, hence enabling informed learner control over the selection and sequencing of that content.

The elaboration theory prescribes a simple-to-complex sequence based on a *single kind of relationship* in the content because it is hypothesized to enable learners (1) to more effectively comprehend the structure of that type of content and hence to more effectively form a stable cognitive structure that is isomorphic with it; and (2) to form the most useful type of cognitive structure with respect to the goals of the course.

Finally, a (simple-to-complex) sequence based on *epitomizing* (rather than on summarizing) is prescribed because it is hypothesized to make the learning more meaningful and less rote by effecting acquisition on the application level rather than on the memorization level.** This is expected to result in easier and more enjoyable learning and better retention.

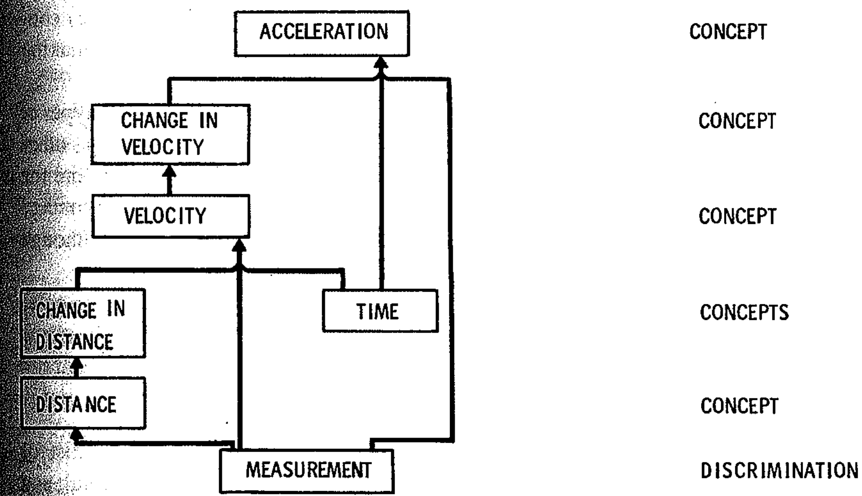
Perhaps the best instructional model will be one that uses some combination of summarizing and epitomizing. Some support for these prescriptions is provided in the last section of this chapter, but there is clearly a great need for research in this area.

2. A Learning-Prerequisite Sequence

A learning-prerequisite sequence (Gagné, 1968) is based on a *learning structure* or learning hierarchy. (The term *learning hierarchy* has come to mean many different things to different people. For instance, may consider parts conceptual

*Editor's note: This is similar to Keller's concern for *relevance* (Chapter 11). Also, for a discussion of the effects of a simple-to-complex sequence on a student's *expectancy for success*, see Chapter 11.

**Editor's note: This also relates to Keller's concern for *relevance* (Chapter 11, pp. 406–415).



Key: The arrow between two boxes on different levels means that the lower box must be learned before the higher box can be learned.

FIG. 10.11 An example of a learning structure.

structures to be learning hierarchies. Hence, we prefer to use the less ambiguous term, learning structure.) A learning structure is a structure that shows what facts or ideas *must* be learned before a given idea can be learned (see Fig. 10.11 for an example). Hence, it shows the *learning prerequisites* for an idea. For example, one cannot learn what a quadratic equation is until he or she has learned what its defining characteristics (e.g., in this case "second power" and "unknown variable") are. Similarly, one cannot learn the principle that "force equals mass times acceleration" until he or she has learned the individual concepts of mass, acceleration, and force. It is also necessary to understand the relationships represented by "times" and "equals." Before the learner has mastered these ideas, he or she is *incapable* of understanding the principle "force = mass x acceleration." However, the learner is capable of substituting values and calculating results (a rote procedure).

Learning prerequisites can be considered *critical components* of an idea. The critical components of principles are: (1) concepts; and (2) change relationships. The critical components of concepts are: (1) defining attributes; and (2) their interrelationships (e.g., conjunctive and disjunctive). And the critical components of procedures are, in the case of regular steps (i.e., the steps represented by rectangles in a flow chart): (1) a more detailed description of the actions involved in the step (i.e., the verbs that describe the step's actions in greater detail); and (2) concepts that relate to those actions (e.g., objects of or tools for the actions), or, in the case of decision steps (i.e., the steps represented by diamonds in a flow chart):

(1) a more detailed description of the factors that influence the decision; (2) concepts that relate to those factors; and (3) rules for considering the factors in making the decision (see Reigeluth & Merrill, 1981, for details).

Learning-prerequisite structures are often confused with the other three types of structures. The best means of differentiating learning structures from the other three types is to consider that learning prerequisites must be acquired before the learner is *able to learn* the subsequent idea. On the other hand, the ideas in conceptual, procedural, and theoretical structures can be learned in any order (although we believe that some orders are better than others.

A *learning-prerequisite sequence* is the presentation of content ideas in an order such that an idea is not presented until after all of its learning prerequisites have been presented (that is, all of its learning prerequisites that the students had not mastered before this lesson).

Relationship to the Other Kinds of Structures. Learning prerequisites exist for every box in all three of the other kinds of structures (conceptual, procedural, and theoretical). Hence, you could picture, say, a kinds conceptual structure on a sheet of paper that is held horizontally in the air. Then, there would be a learning structure dangling down from each box in that conceptual structure. It is also common for a concept in a conceptual structure to also appear as part of a principle in a theoretical structure or as part of a step in a procedural structure.

3. Summarizer

In instruction it is important to systematically review what has been learned, so as to help prevent forgetting. A summarizer is a stretegy component that provides: (1) a *concise statement* of each idea and fact that has been taught; (2) a reference example (i.e., a typical, easy-to-remember example) for each idea; and (3) some diagnostic, self-test practice items for each idea. There are two kinds of summarizers in the elaboration theory. One is an *internal summarizer,* which comes at the end of each lesson and summarizes only the ideas and facts that are taught in that lesson. The other is a *within-set summarizer,* which summarizes all of the ideas and facts that have been taught so far in the "set of lessons" on which the learner is currently working. A set of lessons is any one lesson, plus the lesson on which it elaborates, plus all of the other lessons (coordinate lessons) that also elaborate on that lesson (see Fig. 10.12).

4. Synthesizer

In instruction it is important to periodically interrelate and integrate the individual ideas that have been taught, so as to: (1) provide students with that valuable kind of knowledge; (2) facilitate a deeper understanding of the individual ideas through comparison and contrast; (3) increase the meaningfulness and motivational effect of the new knowledge by showing how it fits within a larger picture (Ausubel,

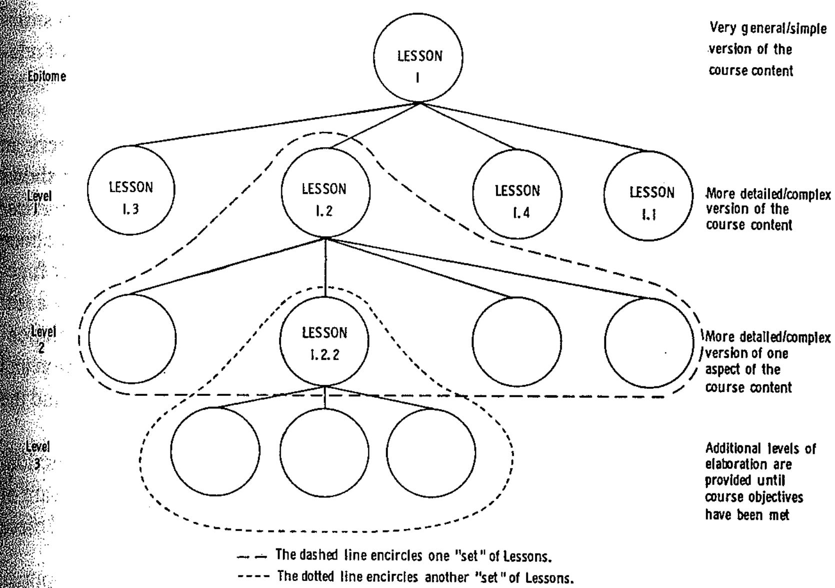


FIG. 10.12 A diagrammatic representation of a set of lessons.

1968; Keller, Chapter 11, this volume); and (4) increase retention (i.e., reduce forgetting) by creating additional links among the new knowledge and between the new knowledge and a learner's relevant prior knowledge (Ausubel, 1964; E. Gagné, 1978; Norman, Rumelhart, & the LNR Research group, 1975; Quillian, 1968).

In the elaboration theory, a *synthesizer* is a strategy component for relating and integrating ideas of a *single type* (e.g., for relating and integrating a set of concepts or a set of procedures or a set of principles). This is done by presenting: (1) a generality in the form of one (or more) of the kinds of knowledge structures (previously described) and, if necessary, explaining what it means; (2) a few integrated reference examples—ones that illustrate the relationships among the ideas; and (3) a few integrated, diagnostic, self-test practice items. A single type of relationship is advocated for each synthesizer so as to not confuse the learner as to what kind of relationship is being depicted by any given line in the diagram. Hence, kinds conceptual relationship should be presented in a different synthesizer (diagram) from parts conceptual relationships (unless a table or matrix structure is used to combine them in a clear way). And procedural and theoretical relationships should be presented apart from each other and from conceptual relationships, even though the same concept (e.g., velocity) may appear in all of those different synthesizers. Like the alternative conceptual relationships, descriptive and prescriptive theoretical relationships should be presented separately; but procedural order and procedural-decision relationships are often best combined into a single procedural structure. Each structure—regardless of type—should be labeled as to the kind of relationship it depicts. It should be evident from this discussion that several synthesizers are likely to be presented at the same general point in instruction.

The elaboration theory calls for the use of two different kinds of synthesizers: an internal synthesizer and a within-set synthesizer. An *internal synthesizer* shows relationships among the newly taught ideas within a lesson. A *within-set synthesizer* shows how the newly taught ideas within a lesson relate to the ideas that have been taught so far in its set of lessons. More specifically, the internal synthesizer functions *horizontally* to show relationships among ideas that were presented by a single lesson. The within-set synthesizer functions both *horizontally* to show relationships among ideas presented by a set of lessons at a single level of elaboration and *vertically* to show relationships between the ideas in that group of lessons and the more general and inclusive ideas that contain them (see Fig. 10.12).

In this way, new ideas are placed within the context of the previous instruction. Through a process of periodic synthesis, the learner is continually kept aware of the structure of the ideas in the course and of the relevance of each individual piece of knowledge to related pieces.

5. Analogy

An analogy is an important strategy component in instruction because it makes it easier to understand new ideas by relating them to familiar ideas (Dreistadt, 1969; Ortony, Reynolds, & Arter, 1978; Raven & Cole, 1978). An *analogy* describes similarities between some new ideas and some familiar ones that are outside of the content area of immediate interest. Fig. 10.13 shows examples of an analogy. An analogy is helpful whenever the to-be-acquired ideas are difficult to understand and lack direct meaningfulness for the learner. By relating this difficult and unfamiliar content to familiar knowledge in some other content area, the new content acquires meaning; it becomes familiar.* For example, a lesson or group of lessons on meter in poetry can be introduced by an analogy that compares metrical patterns in poems to rhythms in music.

As long as the instruction carefully identifies the limits of the relationship and the points at which the analogy breaks down, an analogy can be a strong and effective strategy component. The larger the number of similarities, the more effective an analogy will be. Also, the larger the number of ideas that can be made familiar through the analogic comparison, the more useful the analogy will be. Moreover, the greater the familiarity and meaningfulness of the analogy to the learner, the more useful it will be. However, if the number of differences between the new and analogic ideas is great, then the analogy may be more confusing than helpful.

*Editor's note: For a discussion of the motivational effects of analogies, see Chapter 11, pp. 403-404.

	NEW IDEA	ANALOGIC IDEA
1.	RESISTOR	VALVE
	BOTH REDUCE THE AMOUNT OF FLOW OF SOMETHING.	
2.	EXPERIMENTAL ERROR	STATIC
	RANDOM INTERFERENCE IS A CENTRAL PART OF BOTH.	
3.	HUMAN BRAIN	COMPUTER
	BOTH STORE, PROCESS, AND RETRIEVE INFORMATION.	
4.	TOUCHING KEYS	TOUCHING A HOT STOVE
	BOTH HAVE THE SAME QUICK MOVEMENT AND LIGHT TOUCH.	

FIG. 10.13 Examples of analogic ideas that can be used to facilitate learning new ideas.

More than one analogy may be available for use at a given time. In such a case, it is often advisable to include more than one, especially if there are considerable individual differences among the learners. Then each learner may be encouraged to skip some of the analogies and to choose the particular analogy that is most useful for him or her. It is also important to note that if highly similar analogous ideas are not part of a learner's prior knowledge, it will still be worth teaching them if the amount of learner effort that they save is greater than the amount of effort that their instruction costs.

6. Cognitive-Strategy Activator

Instruction is more effective to the extent that it requires learners to consciously or unconsciously use relevant cognitive strategies (Bruner, 1966; Gagné, 1977; Rigney, 1978), because how a student processes the instructional inputs is a crucial link in the learning process. *Cognitive strategies,* sometimes called generic skills, include learning skills and thinking skills that can be used across a wide variety of content areas (hence the name "generic"), such as creating mental images and identifying analogies.

Cognitive strategies can and should be activated during instruction. Two means of accomplishing this have been described by Rigney (1978). First, the instruction can be designed in such a way as to force the learner to use a particular cognitive strategy, often without the learner's being aware that he or she is, in fact, using that strategy. These *embedded* strategy activators include the instructional use of pictures, diagrams, mnemonics, analogy, paraphrases, and other devices that force the learner to manipulate or interact with the content in certain specific ways.

The second form of activator is the *detached*-strategy activator, which directs the learner to employ a previously acquired cognitive strategy. Directions to "create a mental image of the process you just learned" or to "think of an analogy for this concept" serve two functions. First, they improve the learner's acquisition and retention of the new content. But just as importantly, the conscious use of cognitive strategies increases the learner's competence with them.

In addition, cognitive strategies can and usually should be taught along with the subject matter of interest. The inclusion of detached-strategy activators, along with some brief instruction on the use of those cognitive strategies (for those learners unfamiliar with them) takes very little instructional time and increases both the effectiveness of the instruction and the learner's capacity to manipulate and understand other similar kinds of learning tasks. Such use of detached activators serves to provide practice that, if interspersed with appropriately labeled examples (embedded activators) for the same cognitive strategies, should help the learner to learn *how* to use those cognitive strategies on his or her own. It should also help the learner to learn *when* to use each cognitive strategy by focusing the learner's attention on the types of cognitive strategies that are appropriate for particular learning tasks. This latter strength becomes an important issue to consider for the next strategy component, learner control.

7. Learner Control

According to Merrill (1979), the concept of learner control refers, in its widest sense, to the freedom the learner has to take command of the *selection and sequencing* of: (1) the *content* to be learned (content control); (2) the *rate* at which he or she will learn (pace control); (3) the particular *instructional-strategy components* he or she selects and the *order* in which they are used (display control); and (4) the particular *cognitive strategies* the learner employs when interacting with the instruction (conscious cognition control). Merrill (1979) has described the characteristics of each of these types of control, as well as the limitations that instruction places on each. The elaboration theory affords possibilities for learner control over the selection of content (1), instructional-strategy components (3), and cognitive strategies (4). (The second category, pace, is only controllable at the micro level.) Merrill hypothesizes a *metacognition* model inside each learner that orchestrates how the learner chooses to study and learn. In terms of this model, we hypothesize that instruction generally increases in effectiveness, efficiency, and appeal to the extent that it permits informed learner control by motivated learners (with a few minor exceptions).

Many opportunities can and usually should be made for the informed learner to select and sequence instructional content and strategies and to activate cognitive strategies in accordance with his or her own metacognition model. With respect to learner control over *content*, elaborative sequencing makes it possible for a learner to pick that aspect of the epitome—or of any other lesson—that interests him or her the most and to study it next. Only a simple-to-complex sequence can allow a learner to make an *informed* decision about the selection of content. The learner can then continue to select more detail in that area, or he or she can return to an earlier lesson and pick a different aspect of it for further elaboration. For more information about learner control over content, see Merrill (1980) and Reigeluth (1979b).

Aside from the selection and sequencing of content, learner control can also be provided for the selection and sequencing of strategy components. The learner could be given greater freedom to decide when and if he or she wants to view a summarizer or a synthesizer or an analogy. The learner could also be given the freedom to select the cognitive strategies that are most appropriate and useful for him or her at that particular point in the instruction.

One of the major ways for giving competent learners a large measure of control over strategy is formating. Clearly *separated* and *labeled* instructional components make it easier for the learner to select and sequence these components according ot his or her personal needs and interests, including the selective review and study of summarizers and synthesizers. Also, clearly separated and labeled cognitive-strategy activators (detached or embedded) increase the learner's fluency with these strategies and permit the learner to choose how he or she will manipulate and interact with the content. They also facilitate review and study of these strategy components.

Micro Strategies

One additional aspect of the Elaboration Theory, although it could hardly be called a strategy component, is that it calls for the use of Merrill's Component Display Theory (see Chapter 9) for designing the instruction on the individual ideas and facts comprising the instructional content (i.e., for designing the instruction on the micro level).

Summary of Strategy Components

In summary, the Elaboration Theory is comprised of seven major strategy components (plus some minor ones that have not been mentioned):

1. An elaborative sequence.
2. A learning-prerequisite sequence.
3. A summarizer.
4. A synthesizer.
5. An analogy.

6. A cognitive-strategy activator.
7. A learner-control format.

In addition, the Elaboration Theory prescribes the use of Merrill's Component Display Theory (see Chapter 9) for teaching each individual idea and fact.

It is hypothesized that instruction is more effective, more efficient, and more appealing to the extent that each of these seven strategy components is employed in the instruction. However, these strategy components could be combined in many different ways. The elaboration model of instruction specifies a particular way of combining them that is hypothesized to optimize learning. The next section of this chapter describes that particular way of combining these strategy components.

THE ELABORATION MODEL

We said earlier that the Elaboration Theory is comprised of *three models* of instruction and a *system for prescribing* these models in accordance with the goals or purpose of a course or curriculum. The seven strategy components just described are present in all three models, but some characteristics of those components vary from one model to another. The constancy of all seven components in all three models allows us to talk about a *general model* of instruction—a set of unvarying characteristics for all instruction designed according to the Elaboration Theory. This general model is described next. It provides a "blueprint" or description of what the instruction should be like, from beginning to end, for objectives in the cognitive domain.

1. Present an Epitome

The general elaboration model of instruction starts by presenting an epitome (a lesson that epitomizes a single type of content and includes whatever of the other types of content are highly relevant). The epitome might start with a *motivational-strategy component* such as the creation of an incongruity (see Chapter 11), but such strategy components have not yet been adequately integrated into the Elaboration Theory. Then it presents an *analogy,* if a good one can be found and is believed to be necessary or useful. Next, it presents the *organizing content ideas* in a "most fundamental, most representative, most general, and/or most simple first" sequence.[1] However, each of these ideas is directly preceded by all of its *learning prerequisites* that have not yet been mastered by all of the target learner population. Each of the organizing content ideas may also be directly followed by any of the other *supporting content ideas* that have been selected as highly relevant to it. Alternatively, it may be best to group all of those supporting ideas for presentation after all of the organizing content ideas have been presented, especially if those supporting ideas are highly interrelated. All of the ideas in the epitome are presented according to *Component Display Theory* specifications (see Chapter 9). Finally, a *summarizer* and a *synthesizer* are presented. The synthesizer shows the part of the organizing structure whose ideas have been taught in the epitome. Also, *cognitive-strategy activators* (embedded and detached) are included whenever they are needed and appropriate, as are additional motivational-strategy components (see Chapter 11).

[1]In the case of procedural organizing content, a forward chaining sequence is recommended for presenting the organizing content ideas.

2. Present Level-1 Elaborations

Next, the general elaboration model makes all of the level-1 lessons available to the learner. There will usually be about four to eight level-1 lessons—lessons that elaborate directly on various aspects of the epitome's organizing content. Each level-1 lesson takes one (or sometimes two) aspects of the epitome's organizing content and presents slightly more detailed or more complex organizing content that elaborates on it. Each lesson has all the characteristics of the epitome lesson described earlier: motivational-strategy components, a new analogy or an extension of the earlier analogy if appropriate, the organizing content ideas directly preceded by their prerequisites and succeeded by their other supporting content, and an internal summarizer and internal synthesizer. Naturally, the Component Display Theory is still used to present each individual idea and fact, and cognitive-strategy activators and additional motivational-strategy components are used whenever needed and appropriate.

However, one additional component is added on to the end of each level-1 lesson: an *expanded epitome*. This expanded epitome begins with a within-set summarizer, which summarizes ideas among the already-taught lessons within that set of lessons. Then it relates the new organizing content (via a synthesizer) to the within-set organizing content that has already been taught. It does this via synthesizers and integrative generalities, examples, and practice, as prescribed by the Component Display Theory (see Chapter 9). This is equivalent to the zoom-out-for-context-and-review activity in the zoom-lens analogy.

Usually the level-1 lesson that elaborates on one aspect of the epitome should not include *all* of the more detailed or complex knowledge on that aspect. Rather, a level-1 elaboration should itself be an epitome of all the more detailed or complex knowledge on that aspect of the epitome, just as zooming in one level provides a slightly more detailed wide-angle view of one part of the whole picture. It is important to note that an aspect is not the same thing as an idea. It is possible that a level-1 elaboration may elaborate to some extent on all of the ideas in the epitome or perhaps even on a relationship among those ideas, or even on an exception to those ideas.

The depth to which a level-1 elaboration should elaborate on an aspect of the epitome is somewhat variable (i.e., the discrete levels on the zoom lens are variable, not always constant and equal in the amount of detail added). The most important factor for deciding on the depth of a given level-1 elaboration is the *student learning load*. It is important that the student learning load be neither too large nor too small, for either will impede the instruction's efficiency, effectiveness (especially for retention), and appeal. The number of ideas that represent the optimal student learning load will vary with such factors as student ability, the complexity of the subject-matter ideas, and student prefamiliarity with the ideas. We expect that the breadth of a level-1 elaboration will usually be fairly difficult to adjust. Hence, optimizing the student learning load in a given elaboration can often be done mainly by varying the depth of the elaboration. But we hypothesize that both ways are equally acceptable.

3. Present Level-2 Elaborations

The general elaboration model makes level-2 lessons available to the learner as soon as he or she has reached mastery on the level-1 lesson on which those level-2 lessons elaborate. Each level-2 lesson is of identical nature to the level-1 lessons except that it elaborates on an aspect of a *level-1* lesson's organizing content instead of elaborating on an aspect of the epitome's organizing content.

4. Present Additional Levels of Elaboration

The general elaboration model continues to make more detailed or complex levels of lessons available to the learner as soon as he or she has reached mastery of the lesson on which those lessons elaborate, until the desired level of detail or complexity (as represented by the objectives of the course) is reached. And each of those lessons is of similar nature to the other lessons, with the exception that it elaborates on an aspect of the previous level's organizing content instead of a higher level's organizing content.

Other Comments

According to the general elaboration model, elaborations that are on the *same level* are very different from each other with respect to the instructional content they contain (i.e., their ideas are very different from each other), but elaborations that are on *different levels* are very similar with respect to their instructional content (i.e., their ideas are very similar), because each level has basically the same content as the previous level, only presented in greater detail or complexity. This provides an important systematic review mechanism.

It should be noted that there are three ways in which systematic review takes place. First, each level of elaboration covers *similar content* to that in the previous level (only with some additional detail or complexity). Learning this more-detailed version of the same content stimulates or incorporates review of that earlier aspect of the course content. Second, the *internal summarizer* at the end of each elaboration reviews the content that was just presented in that elaboration by providing a concise generality for each idea. And third, the *expanded epitome* (including the external summarizer) at the end of each elaboration constantly reviews and integrates the major content that was presented in earlier elaborations.

Summary of the Elaboration Model

In summary, the elaboration model is as follows (see Fig. 10.14). First the *epitome* is presented to the student. Then the *level-1 lessons* are made available to elaborate on the various aspects of the organizing content in the epitome. An internal summarizer and synthesizer come in the last part of each lesson, and an *expanded epitome* is presented after each lesson. Also, as soon as a learner reaches mastery on a level-1 lesson, *level-2 lessons* are made available that elaborate on that level-1 lesson. Additional levels of lessons are made available in the same way—an elaboration followed by an expanded epitome—until the level of detail specified by the objectives is reached.

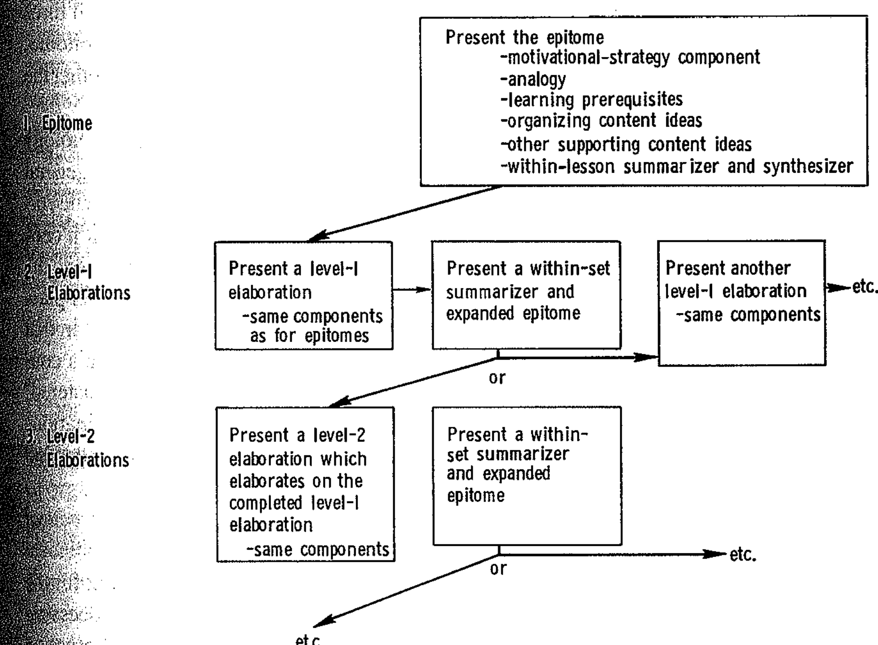


FIG. 10.14 A diagrammatic representation of the general elaboration model.

Each lesson, including the epitome, should contain: motivational-strategy components if needed, an analogy if appropriate, the organizing content ideas directly preceded by their prerequisite supporting content and succeeded by their other supporting content, and an internal summarizer and internal synthesizer. The component display theory is used to present each individual idea and fact, and cognitive-strategy activators and additional motivational-strategy components are used whenever needed and appropriate. In addition, each lesson except for the epitome should end with an expanded epitome, which begins with a within-set summarizer and proceeds to horizontally and vertically integrate the organizing content (and occasionally supporting content) via synthesizers, integrative generalities, examples, and practice.

VARIATIONS OF THE MODEL

The Three "Organizations"

As we said earlier, several different models of macro organization can be generated from the general model. In fact, the Elaboration Theory is comprised of: (1) three different models; and (2) a basis for prescribing when each model should be used. These three different models are the conceptually organized model, the procedurally organized model, and the theoretically organized model. Although all three models have the characteristics described previously, the nature of the epitome, the elaborations, and the synthesizers varies considerably according to whether the organization of the course is conceptual, procedural, or theoretical.

For example, a *conceptually organized* course, such as a course in basic biology might be, uses a conceptual (perhaps matrix) structure, in which the most general concepts are presented in the epitome (as, for example, the animal phyla). The epitome is quite different from the other two types of epitome, not just in that it centers around concepts, but also in that its organizing content is more general than the remaining organizing content (i.e., most of the remaining concepts are either parts or kinds of the epitome's concepts). Succeeding elaborations are different in that they provide more detailed and narrow subclassifications of the epitome's concepts, until the most detailed concepts specified by the objectives are mastered. Students learn to make progressively finer and more precise discriminations among narrower and more exclusive categories as levels of elaboration progress. The synthesizers also differ in that they utilize conceptual structures.

On the other hand, a course in applied statistics would probably use a *procedural organization,* in which the simplest and most generally applicable statistical procedure is taught first (at the application level) as the organizing content for the epitome. A procedural epitome is often identical to what information-processing analysts refer to as the "shortest path" through a procedure (or a set of alternative procedures). The remaining procedures are not parts or kinds of the epitome's procedure; rather they are more complex and often more narrowly focused procedures that are necessary for achieving basically the same ends under different and often more difficult conditions. The elaborations are different from the other two kinds of elaborations in that they teach progressively more detailed and complex condition-specific versions of or alternatives to the simple epitome procedure, until a large variety of procedures—each of which is used under fairly limited conditions—has been taught. The synthesizers mostly take the form of procedural structures, although some kinds and parts structures are often used.

Finally, an introductory course in economics would probably use a theoretical organization, in which the most fundamental principle of economics (the law of supply and demand) is taught first (at the application level) as the organizing content for the epitome. This principle is often identified by asking an experienced teacher or subject-matter expert, "If you could only teach one principle (or two), what would it be?" The elaborations are different from the other two kinds of elaborations in that they teach progressively more complex, narrow, and situation-specific versions of, or qualifications of, the fundamental epitome principle(s), until the desired level and breadth of explanation or prediction have been reached. The synthesizers mostly take the form of branching chains of cause-and-effect statements, which are usually represented diagrammatically (if they are qualitative statements) but are occasionally represented mathematically (if they are quantitative as well).

Moreover, the need to nest particular *types of supporting* structures within each elaboration requires further variations among the models. For example, conceptual supporting content requires a different kind of synthesizer than does procedural supporting content. Thus the nature of each type of structure, both organizing and supporting, represents a different variation of the general model.

It should be noted that any of the three organizations can be used for almost all subject areas. For example, although a conceptual organization is usually more consistent with the goals of a high school biology course, a theoretical organization would be quite reasonable (centered around such principles as survival of the fittest and genetic variability), and a procedural organization would also be possible (e.g., a course centered around how to make hybrids).

Other Kinds of Variations

In addition to these standard variations among the three models based on the type of organizing content selected, variations of the general model also derive from the nature of the "zooming in" from simple to complex. These variations could be viewed as the learner-controlled model, the system-controlled model, and the fixed model. The *learner-controlled* model was described as the general model. In the *system-controlled* model, the teacher or other delivery medium uses information about each learner to select and sequence the content and strategy components. Finally, the *fixed* model uses one set of content and strategy components (including sequence) for all students.

The Elaboration Theory hypothesizes that the learner-controlled model should usually be used whenever possible, as long as the learners are properly instructed in the effective use of learner control. The increased motivation that results when a learner is allowed to study in depth a particular aspect of the organizing content that is especially interesting to that individual will usually completely offset any decrease in learning efficiency that might result from this variation; and it is likely that increases in learning efficiency would be the rule rather than the exception, due mostly to increased motivation.

In addition, it should be noted that there are several types of *fixed models*. For example, following the epitome, the instruction could zoom in on all level-1 elaborations before proceeding with any level-2 elaborations, thus offering the learner the same level of detail and complexity across the breadth of the ideas covered in the epitome. Alternatively, the instruction might zoom in on only one level-1 elaboration, then proceed to a level-2 elaboration on only that content presented in that single level-1 elaboration, and then proceed to a level-3 elaboration on that same small set of ideas. This latter variation would provide learners with considerable depth on one part of the organizing content before giving them much breadth at all. Hence, the former variation of the fixed model will usually be preferable when the fixed model is necessary.

Summary of Variations

In summary, two important types of variations are possible within the elaboration model. The first concerns the type of *organization* selected for a particular course or curriculum. The second concerns the degree of *adaptability* of the sequencing to the individual learner and the degree of control given learners over the sequencing in the "zooming-in" process. Hence, the second type of variation also concerns the development and use of metacognition models with which the learner approaches learning tasks.

USING THE ELABORATION THEORY

We have developed a fairly detailed set of procedures for designing instruction according to the Elaboration Theory (see Reigeluth, Merrill, Wilson, & Spiller, 1978, for general procedures; see Reigeluth & Darwazeh, 1982, for the conceptual approach; see Reigeluth & Rodgers, 1980, for the procedural approach; and see Sari & Reigeluth, 1982, for the theoretical approach). Although the procedure varies in important ways depending on which of the three models is chosen, all three procedures are characterized by six general steps (see Fig. 10.15).

First, one must select an organization—either conceptual, procedural, or theoretical—on the basis of the goals or purpose of the instruction. Second, one must develop an organizing structure that depicts the organizing content (either concepts, procedures, or principles) in the most detailed/complex version that the

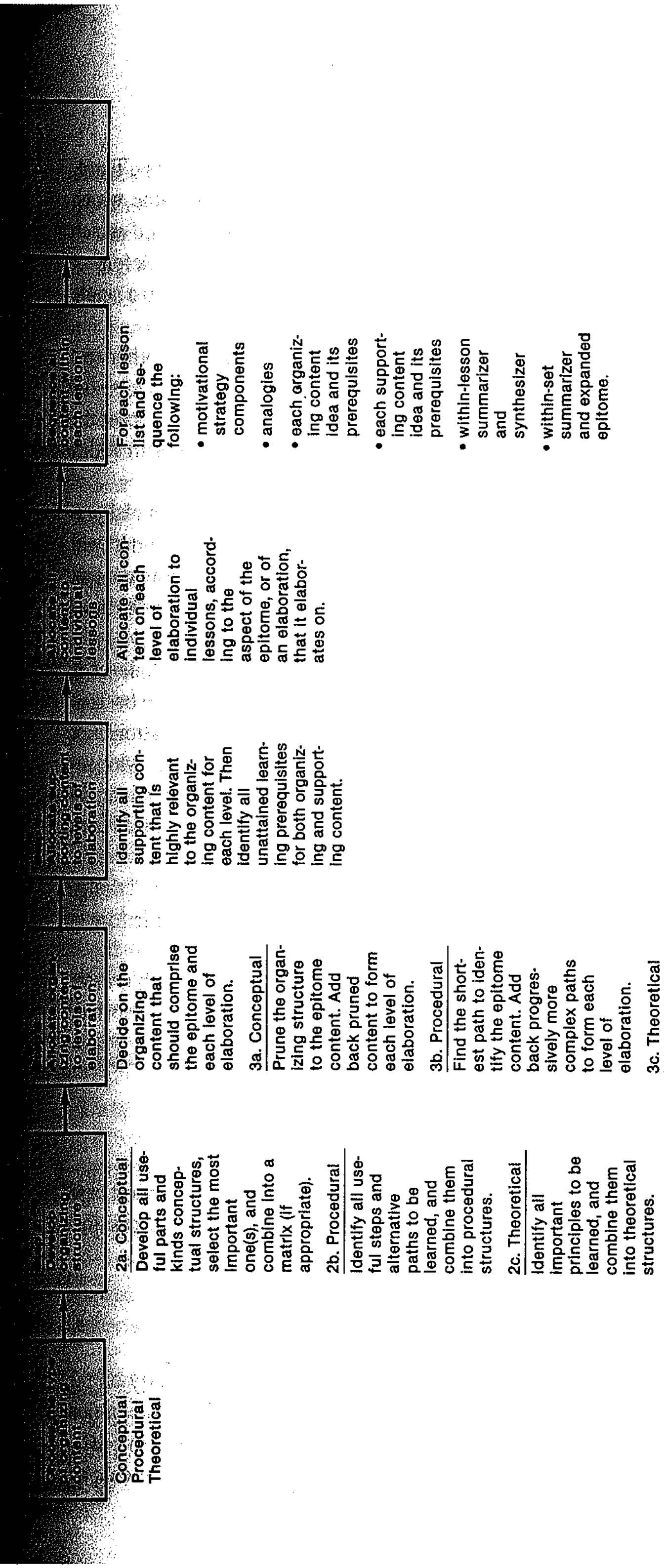


FIG. 10.15 The six step design procedure for designing instruction.

student needs to learn. This is a form of content analysis or task description. Third, the organizing structure is analyzed in a systematic manner to determine which aspect(s) of the organizing content will be presented in the epitome and which aspects will be presented in each level of elaboration. In this way the "skeleton" of the instruction is developed on the basis of epitomizing and elaborating on a single type of content.

The fourth major step is to embellish the "skeleton" by adding the other two types of content plus facts at the lowest appropriate levels of detail. Thus the remaining kinds of subject-matter content are "nested" within different parts of the skeleton. Learning prerequisites are among the considerations that enter in at this point.

Having allocated all of the instructional content to the different levels of elaboration, it is now important to establish the scope and depth of each lesson that will comprise each level. The scope is usually predetermined by the organizing content ideas and their important supporting content. The depth is determined on the basis of achieving an optimal student learning load, as described earlier.

Sixth and finally, the internal structure of each lesson within each level is planned. The sequence of ideas and facts within a lesson is decided on the basis of several factors, the most important of which are learning-prerequisite relationships and contribution to an understanding of the whole organizing structure. Motivational-strategy components and analogies are planned, and the locations of internal synthesizers and summarizers are also determined. Finally, the content of each expanded epitome is specified.

This concludes the "macro" design process, at which point the "micro" design process begins: decisions as to how to organize the instruction on a single idea or fact.

We have spelled out these procedures for designing instruction in much greater detail elsewhere (Reigeluth & Darwazeh, 1982; Reigeluth et al., 1978; Reigeluth & Rodgers, 1980; Sari & Reigeluth, 1982).

SUPPORT FOR VALIDITY

The Elaboration Theory is very new and therefore lacks an extensive support base for its validity. Nevertheless, some support is to be found from three sources: formal research, learning theory, and educational practice.

Research Support

Although some research is currently in progress, only one study directly on the Elaboration Theory has been completed. However, because the Elaboration Theory integrates much work of other theorists and researchers, there is empirical support for aspects of the Elaboration Theory. It is beyond the scope of this chapter

to conduct an extensive review of such research support. The following is a summary of the major lines of existing empirical support.

The research literature on advance organizers lends some support to the strategy of a general-to-detailed sequence (see Mayer, 1979, for a review and analysis of that literature). However, this research is mute on the question of epitomizing versus summarizing. The "path-analysis" literature for the information-processing approach to task analysis lends some support to epitomizing as opposed to summarizing. A procedural epitome is often the same as what information-processing analysts refer to as the "shortest path" through a procedure (see for example, P. Merrill, 1978).

With respect to the learning-prerequisite sequencing aspect of the Elaboration Theory, the research on hierarchical approaches to sequencing lends direct support to this aspect of the Elaboration Theory. See White (1973) and Resnick (1976) for excellent reviews of this research literature.

Although this piecemeal research does lend some support to the Elaboration Theory, it leaves many important questions unanswered. Of particular importance is research on the way in which all of the pieces have been integrated into the Elaboration Theory. This kind of research can only be done by including a treatment group that receives everything that the Elaboration Theory prescribes. The disadvantage is that such research requires extensive development of instructional materials, especially because it is likely that, for relatively short pieces of instruction, the human mind can compensate for most of the weaknesses in macro strategies. Full semester or year courses are likely to show some important differences, but they are very expensive to develop treatment materials for and to conduct. As of yet, federal agencies have been unwilling to support such expensive research. Until there is a change in this situation, research support for the Elaboration Theory will remain inadequate.

Learning-Theory Support

Theoretical support for the validity of the Elaboration Theory comes from several sources (see Merrill, Kelety, & Wilson, 1981, for a more extensive review). Two extremely important areas of cognitive psychology that provide the most support are: (1) theories about cognitive representational structures; and (2) related memory processes such as encoding, storage, and retrieval mechanisms. A discussion of these two areas of cognitive psychology is followed by a description of ways in which each supports specific aspects of the Elaboration Theory. Finally, several other sources of support are discussed.

Cognitive Structures

An early, primary focus of cognitive theory appears in the work of Ausubel (1963, 1964, 1968), who argued that new knowledge is acquired and acquirable to the extent that it can be meaningfully related to and subsumed within existing (i.e., previously learned) knowledge. Ausubel maintained that knowledge is organized within the learner's memory primarily in hierarchical fashion. More general, inclusive, and abstract content subsumes (or assimilates) newer, more specific and concrete knowledge. The more firmly anchored and differentiated these subsuming structures are, the more useful they are as ideational anchorage. Additionally, Ausubel proposed that the various pieces of information integrated within a particular knowledge structure are highly interrelated, linked by some type of semantic similarity. Thus, previously acquired, more general and abstract knowledge can facilitate the acquisition of new subordinate content.

Ausubel described three necessary conditions for the meaningful learning of new content. The learner must possess a stable cognitive structure capable of subsuming the new content; the new content must be nonarbitrary (i.e., capable of being subsumed meaningfully in nonverbatim fashion); and the learner must have a cognitive "set" of previously acquired knowledge already in cognitive store to which the new content can be meaningfully related.

Ausubel's conceptualization of learning as assimilation (or, to use his earlier term subsumption) is echoed and extended in Mayer's (1977, 1979) theory of "assimilation to schema." A schema, according to Mayer, is any grouping of information that is organized in some meaningful fashion. Schemata facilitate the integration of the knowledge by serving an assimilative (or subsumptive) function: new knowledge is assimilated into a hierarchy of progressively more detailed, specific, and differentiated content within the learner's cognitive store. Thus, the basic learning process is the assimilation of new knowledge within hierarchically ordered schemata.

Mayer's theory posits that the nature of the learner's existing cognitive structure (i.e., the content and organization of knowledge in memory) is the major factor influencing the meaningful acquisition of new knowledge. In particular, both Ausubel and Mayer emphasize the importance of shaping the content and arrangement of antecedent learning conditions so as to facilitate the assimilation of new knowledge. The use of assimilative sequences of content that begin with very general and inclusive information can provide ideational anchorage for more specific and detailed information, thus providing the means for integrating new content within existing knowledge.

More explicit and detailed models of schema theory have been developed by Quillian (1968), Norman and Rumelhart (1975), and Anderson (Anderson, Spiro, & Anderson, 1978; Anderson, Spiro, & Montague, 1977). In these theories, schemata are perceived as organizational structures that serve both to interrelate separate pieces of information into a single conceptual unit and to channel new information to appropriate organizing structures on the basis of relatedness or semantic similarity. These schemata serve both to provide a representational scheme for the organization of knowledge and to offer a theoretical framework for accounting for the acquisition of new knowledge. According to Anderson et al. (1978), the schemata a learner already possesses are the primary determinants of what content the learner will be able to acquire.

Norman and Rumelhart (1975) view schemata as analogous to language structure. In their theory, information can be represented as a network of interrelated concepts and contexts that modify and are modified by incoming knowledge. Schemata permit the making of inferences by providing contextual information that allows, and defines the limits of, conclusions not directly contained within the related pieces of information constituting a schema.

Proponents of semantic networking theories (Norman & Rumelhart, 1975; Quillian, 1968) emphasize that schemata form multiple links with each other such that each piece of information is ultimately related to every other piece. Moreover, the relationships are diverse in nature; they are directional and substantial and determine the nature of what is acquired, stored, and retrieved. These relationships include subordinate, superordinate, and coordinate linkages; Collins and Quillian (1969, 1970) have demonstrated that retrieval is a function of the locatability of content within hierarchical structures.

Memory Structures

Research on the nature of encoding processes in memory has provided evidence for two kinds of memory: episodic and semantic. Semantic encoding processes are associated with deeper, more complex processes and more durable memory traces. Craik's work with semantic encoding processes (Craik & Lockhart, 1972; Craik & Tulving, 1975) indicates that information is encoded and stored in organizing structures similar to schemata. Both Estes' (1970) conceptualization of *control elements* (semantic categories that subsume appropriate pieces of information) and Kintsch's (1970) notion of *markers* (types of semantic topics that assimilate and store bits of related information) describe mechanisms and structures through which incoming information is analyzed, interpreted, and related to existing knowledge structures in memory. Similar notions of semantic organization have been proposed by other theorists. All assume that semantically encoded information is stored in a hierarchically interrelated manner with topical categories as focal units. Norman and Rumelhart's (1975) semantic networks represent one approach to the organization of knowledge in memory in terms of relationships among ideas. Because any one idea can be encoded in many different ways, depending on which of its semantic attributes are salient for any given structure, multiple relational linkages are created between that content and various existing knowledge structures, resulting in a broad network of interrelated knowledge.

Retrieval processes are generally characterized in terms of search mechanisms. Norman and Bobrow (1979) describe two separate stages of search operations. The first stage involves creating a description of the desired target information; the second involves the actual searching, including a recursive review of memory structures and ideas until the targeted information is identified. Anderson et al.

(1977) and Norman and Bobrow (1979) conceptualize such a search process in somewhat different forms; however, the common thread through these and other similar retrieval models involves the assumption that memory consists of highly organized knowledge structures through which searches proceed in hierarchical fashion, from the most general and inclusive to the progressively more detailed and specific knowledge, until the targeted content is located. Thus retrieval is facilitated or hindered to the extent that organizational structures in memory are available as guides for search operations.

Cognitive Psychology and Elaboration Theory

The assumptions and propositions of cognitive models of learning and of acquisition, storage, and retrieval processes previously described provide direct support for the Elaboration Theory. First, the subsumption, assimilation, and schema theories all imply the instructional use of a *general-to-detailed sequence* of content that begins with the most general and inclusive set of constructs available to provide ideational anchorage for the subsequent content. Progressively more detailed, specific, and complex ideas can then be acquired more easily as derivations or elaborations of the more general content. The use of a general-to-detailed sequence of content thus provides the learner with a progression of anchoring knowledge that subsumes, integrates, and organizes the more detailed or complex knowledge.

Second, cognitive learning theories argue the importance of *providing or activating* particular ideas in memory that are at an appropriate level of generality and inclusiveness for serving as ideational anchorage for new knowledge. Such ideas serve several important functions. They provide the *scaffolding* for later learning by their ability to incorporate, integrate, and assimilate more detailed information. They make explicit the *relevance* of later information. And they provide *form and structure* for the later content by identifying both kinds of relationships to be learned and the individual ideas involved in those relationships. In particular, the elaboration theory advocates the use of two principal kinds of relational strategies: (1) a general-to-detailed sequence; and (2) synthesizers (which provide progressive integration and reconciliation of content at each level of detail). Both of these strategies rely heavily on types of knowledge structures in terms of both a single, pervasive organization structure and appropriate supporting structures.

The use of the general-to-detailed sequence is supported by the assimilation and schema theories' assertions that the subsumptive function served by schemata in incorporating and integrating new knowledge at varying levels of generality and inclusiveness facilitates the creation of schemata for assimilating more detailed and specific content. As new knowledge is integrated within the developing hierarchical structure, learning is made more efficient and effective.

Synthesizers provide integration of content at regular points during the general-to-detailed progression of ideas and explicitly teach the interrelatedness of ideas. The resulting synthesis assists the learner in comprehending and utilizing the particular kinds of relationships that characterize a given content area. Equally, the use of a single type of organizing structure makes explicit the critical primary interrelationships that constitute a particular idea. Both organizing and supporting structures provide functional encoding structures for the learner. At each level of elaboration, the expanded epitome assists the learner in integrating the various supporting structures within the primary organization structure.

Moreover, the principle of providing an organizational schema in the form of an epitome results in an encoding structure that requires less processing effort by the learner, because content in the epitome is selected for the learner in a manner compatible with what is already known about encoding mechanisms. Expanded epitomes further facilitate encoding operations through indicating the semantic linkages to be formed at each level of elaboration. The use of a general-to-detailed or simple-to-complex sequence and the periodic synthesis and reconciliation of content create an input structure reflective of our current understanding of the organization and operations of memory.

Additionally, retrieval, in the form of search processes through memory, is facilitated to the extent that information in memory is organized in hierarchically integrated—that is, searchable—form. Also, the greater the number of interrelationships accessible to search operations, the more unlikely it is that failure of a particular retrieval strategy will preclude location of target information. Instead, the learner has available multiple avenues of accessibility through activation of alternate relational paths.

Support for Additional Strategy Components

Another strategy component hypothesized to increase the relatability and stability of new knowledge is the analogy. Analogies function as lateral anchorage between familiar or previously acquired content and new knowledge. By identifying points of tangency between existing knowledge structures and new information and by helping learners to perceive the new in terms of the previously acquired, the analogy assists learners in integrating new, highly unfamiliar content meaningfully.

Ortony (1975, 1976; Ortony et al., 1978) asserts the importance of analogic structures (including metaphor and simile) as both communicative and instructive tools. He argues that such verbal devices assist literal language by permitting us to fill in the gaps created by a language's inability to communicate adequately the continuous nature of experience. Such structures communicate large chunks of experience that cannot be captured in literal terms. At their best, they transmit entire structures of meaning far beyond the capacity of denotative symbol systems. Ortony cites Paivio's (1979) work with imagery as evidence of the effectiveness of figurative devices as instructive tools.

Paul Merrill's work with information-processing models of task analysis underlies the development of strategy prescriptions for content defined as having procedural organization goals. When the subject matter to be acquired is algorithmic in nature, P. Merrill (1976, 1978) argues for the use of path analysis, which results in a sequence of component skills or operations similar to the Elaboration Theory's simple-to-complex epitomization approach.

Robert Gagné's contribution to the theoretical bases of the Elaboration Theory are more primal and pervasive. His concern for developing a theory of learning that accounts for the various different capabilities a learner may acquire led him to postulate his cumulative theory of intellectual-skills acquisition. Gagné (1977) argues that certain kinds of skills must be acquired before other kinds can be acquired. The learning-prerequisite sequences prescribed by the elaboration theory are based on this learning theory, and all the related research applies equally to validate this aspect of the Elaboration Theory.

Bruner's (1960, 1966) *spiral curriculum* is an approach to sequencing instruction that entails teaching ideas initially in a greatly simplified yet "intellectually honest" form, and periodically cycling back to teach those same ideas in progressively more complete and complex forms, like an ever-widening and rising spiral. Although the original intention of the spiral was for it to be applied to a whole curriculum, its intent and function are highly similar to the intent and function of the elaboration theory.

Norman's (1973) *web-learning* model provides similar parallels with Elaboration Theory. In his model, Norman advocates use of an initial broad conceptual outline of to-be-acquired content, followed by progressively more detailed and specific information. The outline serves the dual purposes of the epitome and single organization structure by teaching specific conceptual relationships as the means of facilitating creation and use of organizational schemata. Again, the hierarchical and integrative structure is the heart of the model.

It should be noted, however, that neither Ausubel's nor Bruner's nor Norman's model prescribes instructional strategies in sufficiently precise and detailed form. The Elaboration Theory has attempted to extend and articulate precisely the necessary strategy components for actual implementation of the cognitive (learning theory) principles discussed earlier. The elaboration theory is a highly precise specification of pedagogical requirements for teaching different kinds of content and for achieving different kinds of goals.

Support from Educational Practice

In addition to the previously cited empirical and theoretical support for the Elaboration Theory, there is some support for the elaboration theory from "the field." We have discovered that, for a theoretical organization, the sequence in which the principles in a field end up being taught is often remarkably similar to the sequence in which they were discovered in that field. Hence, textbooks and teachers who have used a chronological approach to teaching theoretically oriented content have often ended up using a sequence that is remarkably similar to that prescribed by the Elaboration Theory. In fact, such a historical approach has been very commonly used for theoretically oriented courses, ranging from physics to economics. The

popularity of this approach seems to indicate that teachers feel it has good results.

Finally, in several teachings of the most fundamental Elaboration Theory ideas to inservice teachers, we have received enthusiastic reception of the approach. Such intuitive appeal to experienced educators, although not experimental data, does nevertheless provide important support for the Elaboration Theory.

CONCLUSION

The Elaboration Theory and development procedures as described here have undergone very limited field testing and no systematic, integrated research. It is likely that aspects of the Elaboration Theory will be modified as research and field testing are performed. For example, it may turn out that having a complete expanded epitome (versus a more narrow one) after every single lesson is inefficient and unnecessary. It is also likely that a large, full-scale field test of the design procedures will reveal more effective and efficient steps for designing instruction according to the theory. In addition to the likelihood of modifications of existing aspects of the Elaboration Theory, there is a continuing need to integrate more of our expanding knowledge about instructional and learning processes.

The Elaboration Theory as developed to date is a tentative move in a much needed direction. It does not yet have the maturity and validation of the currently used approaches to instructional design on the macro level. But the need for such integrative alternatives should be clear. Hopefully, the Elaboration Theory will contribute towards meeting that need.

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