Moving from organizing our own thoughts, we showed pattern notes as a means of recording lectures, and saw how our original notion of a pattern with only one central theme had to be widened to include several major themes. We considered its use for committee situations and two-person discussions.

We showed that pattern notes could sum up a report on one page.

Finally, we looked at the origin of pattern notes and the links to other relational patterns such as critical path networks, PERT, precedence diagrams, topical networks, algorithms, Gagné hierarchies, and elaboration theory.

In all these cases, the major advantage of pattern notes was their ability to organize information relationally, showing complex interdependencies more readily than linear notes. The more complex the subject, the greater the advantage pattern notes have over traditional linear notes.

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4.

Writing and Evaluating Textbooks: Contributions from Instructional Theory

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The purposes of this chapter are (1) to indicate that instructional theory can do much to improve the quality of textbooks, (2) to briefly discuss two theories of instruction which are attempting to integrate a broad range of our knowledge about instruction into a form that is most useful to textbook writers, and (3) to overview some procedures for writing textbooks, for evaluating textbooks, and for revising textbooks. Hence, this chapter serves mainly a motivational and introductory function. It is *not* intended to teach you how to use the procedures that are overviewed. Nor is it intended to teach you a proficient understanding of the two theories that are discussed. To truly teach a proficient understanding of the theories and to teach a proficient use of the procedures would require far more than the allotted space for this chapter.

It is important to realize that different purposes of writing require different styles and formats of writing. Newspaper articles have one kind of format, argumentative essays have another, short stories have another, and instruction has yet another (in fact, it has several). Given the purposes of this chapter, a cross between a newspaper article and an argumentative essay would perhaps be the most appropriate format (although we cannot claim much expertise at either). Hence, the ideas that are discussed in this chapter would be inappropriate to use for the design of the chapter. Rather, references are included as to where you can learn more about the ideas discussed herein.

The following is an indication of what this chapter contains and how it is organized:

I. *The Importance of Instructional Theory in Writing and Evaluating Textbooks.*
   Instructional theory indicates how to improve the instructional quality of textbooks, which will be of special benefit to disadvantaged students, since they are hurt most by poor quality textbooks.

II. *Advances in Instructional Design: Component Display Theory and Elaboration Theory.*
   Component display theory and elaboration theory are intended to integrate existing knowledge about instructional design into optimal models of instruction. They prescribe different models for different conditions (goals, content, learners, etc.). Each theory is analyzed in terms of the basic propositions on which the theories are based.

III. *A Procedure for Designing and Developing Textbooks Using Elaboration Theory.*
   The seven-step design and development procedure is intended for use in a team approach to textbook writing. It describes the content analysis, methods selection, and development phases of instructional development models. The use of this procedure results in the determination of what ideas to teach, how to sequence those ideas, and how to present each idea.

IV. *A Procedure for Evaluating Textbooks Using Elaboration Theory.*
   Evaluation (and revision) of existing textbooks is a very important activity for improving the instructional quality of textbooks. A procedure is outlined for performing an "intrinsic" evaluation of an existing textbook on the basis of the elaboration theory and its subset: component display theory.

V. *A Procedure for Revising Textbooks Using Elaboration Theory.*
   Revision of existing textbooks (after evaluating them and finding problems with them) is another important activity for improving the instructional quality of textbooks. The revision procedure determines ways to correct each instructional problem identified as a result of the evaluation procedure.

VI. *Conclusion.*
   More work is needed to integrate the proven principles of instructional design into theory. A major conscious effort in building better models now will enhance our ability to realize the potential of instructional design theory to improve the quality of textbooks.

The Importance of Instructional Theory in Writing and Evaluating Textbooks

Part of the importance of instructional theory for textbook writing and evaluation lies in the importance of textbooks. Current practice testifies that teachers tend to adopt—or even become "slaves" to—the content and organization of the textbooks they use (Rosecky, 1978; Yarger & Mintz, 1979). Also, Phase Two of the Beginning Teacher Evaluation Study (by McDonnald) found that the great majority of a student's productive learning time was spent in interacting with *materials* (usually textbooks), while only about five percent of their productive learning time was spent in interacting with the teacher. Hence, anything that improves textbooks is likely to have a major impact on learning. And this is where instructional theory comes in.

Instructional theory is a body of knowledge about instruction. Unlike curriculum theory, which focuses more on *what* to teach, instructional theory focuses more on *how* to teach (Snelbecker, 1974). Its major purpose is to improve the quality of instruction. It can do so by making it more *effective*—that is, by increasing the amount of learning and reducing the amount of forgetting. And it can do so by making instruction more *efficient*—that is, by decreasing the amount of time and effort required to learn the same amount of knowledge. And it can do so by making instruction more *appealing*—that is, by making learning more enjoyable and increasing the learner's desire to learn more. Of course, improving the quality of instruction in one of these three dimensions often has a positive effect on the other two also.

As a discipline, instructional theory is very young and far from being able to achieve its potential for improving the quality of textbooks, teacher behaviors, and other forms of instruction. But tremendous progress has been made during the past ten years. Ways of presenting knowledge are being identified, analyzed, and improved. And the kinds of situations in which each of those ways is better than all other known ways are being identified. Research and field testing have been major parts of both of these kinds of activities, so that instructional "theory" is now comprised of a substantial body of validated knowledge about instruction. And unlike learning theory—which is usually difficult to apply to the improvement of instruction—instructional theory is easily and directly applied by practitioners: it is a sorely-needed link between learning theory and educational practice (Dewey, 1900; Snelbecker, 1974).

Perhaps the greatest need for using instructional theory in textbook writing is reflected in the plight of slower and disadvantaged students in our classrooms. Most current textbooks are far from being stand-alone learning resources—in other words, only the brightest students (if any at all) can learn what needs to be learned without the teacher's help. Since, as was mentioned above, the great majority of learning results from interacting with materials, this practically guarantees that slower and disadvantaged students will not receive the instruction that they need in order to learn. Instructional theory can help to make textbooks an effective stand-alone resource for such students, while at the same time—through formatting techniques—not burden the brighter students with unnecessary material. In fact, such use of instructional theory for textbook preparation will also make learning faster and more enjoyable for average and gifted students. Through special formatting techniques, it is also possible that a single text can provide truly individualized instruction that meets the needs of students with different cognitive styles, abilities, and prior content knowledge (see section on "learner control" below).

Improved textbook quality would not at all eliminate the need for the teacher; rather, it would change the teacher's role a bit. First, more individual and small-group contact would become possible. Second, the teacher would be able to focus more on motivating students and on individual remediation where necessary. Third, since the basic content skills and knowledge will have been acquired prior to the class period, class time could be spent on more enjoyable and equally important activities intended to promote transfer, long-term retention, and even the development (through the content under study) of higher-level cognitive strategies, learning strategies, and generic skills (see, e.g., O'Neil, 1978). In fact, instructional theory can help to organize textbooks such that they help students to acquire these higher levels of knowledge.

Although instructional theory has a long way to go before it reaches its full potential for improving textbooks, we believe that we currently have the capability to make significant improvements over the textbooks that are currently produced. However, we would like to emphasize that, because instructional theory is in its adolescence, textbook writers and other instructional designers must not rely on instructional theory (however "proven" it may be) to the exclusion of intuition and trial-and-revision. In fact, it is likely that good instructional designers will always rely to some extent on these two additional sources of knowledge. However, to the extent that a validated knowledge base about instruction can reduce one's reliance on intuition and trial-and-revision, the textbook writing process is likely to become less expensive and more reliably effective.

A fundamental argument of this chapter is that textbooks should be written by a *team* comprised of at least one experienced teacher and one instructional designer. This need not make the cost of textbook writing much more expensive, because designer time usually runs between one-eighth and one-fourth the amount of teacher time required. And the benefits in terms of improved effectiveness should be substantial.

Advances in Instructional Design: Component Display Theory and Elaboration Theory

During its infancy, the field of instructional design was focused on very general and vague method variables, such as discovery vs.

expository, lecture vs. discussion, and inductive vs. deductive methods. But it was soon discovered that there was more variation within each of these types of methods than between them.

This led instructional theorists and researchers to devote most of their efforts to analyzing methods of instruction into more elementary *components* and studying the effects of each such "strategy component" under fairly controlled conditions. This emphasis produced a substantial amount of knowledge about instruction in the form of better strategies and principles for making instruction more effective, efficient, and appealing. However, this knowledge has been either too piecemeal or too vague to be optimally useful to textbook writers and other instructional designers. Even though this emphasis on investigating very precise, elementary, strategy components has been an important phase in the development of the field, the resulting knowledge does not help designers and textbook writers to combine strategy components into optimal configurations for the design of their instruction.

Consequently, emphasis within the field of instructional design is beginning to turn to the *integration* of these highly reliable and validated principles into complete, prescriptive *models* for the design of instruction. For a description of some of the most important attempts at such integration, see Reigeluth (in press). The following is a brief summary of some recent work that has been done along these lines.

There are at least two major types of design considerations in writing textbooks: (1) *micro* considerations, which apply to teaching a *single* idea (such as the use of examples and practice); and (2) *macro* considerations, which apply to the teaching of *many* related ideas (such as sequencing and systematic review). About eight years ago, M. David Merrill and his associates began to integrate much of the existing knowledge about micro design considerations (for single ideas) into five major models of instruction. Those models, along with prescriptions for their optimal use, are referred to as Component Display Theory. About six years ago, C.M. Reigeluth and M.D. Merrill began to integrate much of the existing knowledge about macro design considerations (for many related ideas) into three models of instruction. Those models, along with prescriptions for their optimal use, are referred to as the Elaboration Theory. These two sets of models (which were designed to fit together) are primarily concerned with the effectiveness and efficiency of instruction within the *cognitive domain*. In addition, the Elaboration Theory devotes a moderate amount of attention to motivational considerations for instruction in the cognitive domain. These two sets of instructional models are briefly described below.

Component Display Theory

Merrill's Component Display Theory (Merrill, in press; Merrill, Reigeluth, & Faust, 1979; Merrill, Richards, Schmidt, & Wood, 1977) is based on the assumption that a given presentation can be segmented into a series of discrete displays, most of which are called "presentation forms." Component Display Theory is based on the following eight propositions:

1. *Primary Presentation Forms.* A segment of instruction should include all three of the primary presentation forms: generality, example, and practice. A segment is defined as that instruction designed to teach a single generality or coordinate set of such generalities.
2. *Primary Presentation Form Sequence.* The primary presentation forms for a given segment of instruction should be sequenced in some variation of generality-example-practice. Acceptable variations include the use of a reference example simultaneous with or previous to the presentation of the generality.
3. *Primary Presentation Form Isolation.* The primary presentation forms for a given segment of instruction should be identified and isolated in such a way that a student can easily locate, skip, or review any given form.
4. *Learner Control.* The student should be encouraged to alter his or her primary presentation form sequence by returning at will to previously presented forms after having studied subsequent displays. The student might return to the generality after studying an example or practice display, skip to a practice display before studying the generality, etc.

5. *Generality Representation.* The generality should be restated, represented in other than verbal form, and/or elaborated via a mnemonic or an algorithm.

6. *Mathemagenic Information.* Example displays should be elaborated via mathemagenic information prompting (such as underlining, bold print, color, exploded diagrams, or other kinds of attention-focusing devices) and more than one form of representation (e.g., a verbal description and a visual representation). Practice displays should include mathemagenic information on feedback, in addition to correct answer or right/wrong knowledge of results.

7. *Attribute Matching.* Example displays should include matched non-examples (i.e., non-examples that are as similar as possible to, and are presented simultaneously with, the examples that are provided). Practice displays should be randomly sequenced and unmatched to non-examples.

8. *Instance Sampling.* Instances in both example and practice displays should be divergent, range in difficulty, be presented in an easy-to-difficult sequence, and/or include a variety of representation forms.

Elaboration Theory

Elaboration Theory (Reigeluth, 1979; Reigeluth, Merrill, Wilson, & Spiller, 1980; Reigeluth & Stein, in press) was developed to integrate knowledge about instruction on the macro level (aspects of instruction that relate to more than one idea). This includes such considerations as the *selection* of the content to be taught, the *sequencing* of that content, the delineation of important *relationships* among the content ideas, and the systematic *review* of the ideas (Reigeluth & Stein, in press).

Elaboration Theory argues that: (1) structural relationships in content should be explicitly taught and tested, resulting in more meaningful, stable learning, and (2) the instructional sequence should be organized around these relationships, following an "elaboration approach" (Merrill, Kowallis, & Wilson, 1981).

Elaboration Theory prescribes one of three models based on the goals of the instruction. Each model is made up of the same seven

major *strategy components* (Reigeluth & Stein, in press): (1) a special type of general-to-detailed sequence for the main structure of the course, (2) a learning-prerequisite sequence within individual lessons of the course, (3) a summarizer at the end of each lesson, (4) a synthesizer at the end of each lesson, (5) analogies where appropriate, (6) cognitive strategy activators where appropriate, and (7) a learner control format. Although these seven strategy components are present in all three models, some of their characteristics vary from one model to another. Each model provides a "blueprint" or description of what the instruction should be like for any piece of instruction.

The most fundamental aspect of Elaboration Theory is its prescription of an *elaborative sequence* for instruction. The instruction should start with the most general or simple ideas that are to be taught and should gradually elaborate on those fundamental ideas by adding layers of detail or complexity, one layer at a time. However, it is important to note that the simple or general ideas do not summarize the course content—rather, they *epitomize* the course content; that is, they are but a *few* ideas which are taught at the *application* level rather than many ideas that are lightly touched on at the remember level.

Another important aspect of an elaborative sequence is that it entails elaborating on a *single type of content relationship* (either conceptual, procedural, or theoretical—hence the three models, one for each type of relationship). The rationale is that elaborating on a *single* type of relationship will result in the student's development of more stable cognitive structures, which in turn should cause better long-term retention and transfer.

The elaborative sequence based on a single type of content relationship provides the "skeleton" or basic structure of the textbook, and the other two types of content are nested within relevant parts of the skeleton. For more information, see Reigeluth (1979, 1980), Reigeluth, Merrill, Wilson, & Spiller (1980), Reigeluth & Rodgers (1980), and Reigeluth & Stein (in press).

A Procedure for Designing and Developing Textbooks Using Elaboration Theory

The procedure to design and develop effective, efficient, and appealing instructional materials according to Elaboration Theory (including its subset, Component Display Theory) varies in important ways, depending on which of the three organizations is chosen: conceptual, procedural, or theoretical. Nevertheless, all three procedures can still be characterized by seven general steps. More detailed variations are described elsewhere (as referenced below).

Using the seven-step procedure which is presented in this section will result in the determination of (1) what ideas should be taught in order to achieve the course goals, (2) how those ideas should be sequenced, synthesized, and systematically reviewed, and (3) what micro strategy components should be used to optimize learning for each idea. The third aspect reflects the Component Display Theory knowledge base that has been incorporated into Elaboration Theory's design and development procedure.

This seven-step procedure is intended for use in a team approach to textbook writing. The major members of the team are (1) a *teacher* who has several years of experience in teaching the subject matter of the textbook, and (2) an instructional *designer* who is experienced in using the seven-step procedure. Additionally, the team might include (3) a practicing expert in the subject matter to be taught, (4) an art/graphics expert, (5) a subject matter assistant, and (6) an editor. Naturally, these people will not all work the same amount of time on the project. Designer time seldom runs much more than a quarter of teacher (or SME) time; and the subject matter assistant (who is less expensive than the experienced teacher) can cost-effectively work up to two or three times as long as the experienced teacher during the writing of the textbook. Hence, a typical project might hire a full-time designer, a full-time experienced teacher, two or three subject matter assistants (development phase only), a half-time practicing expert in the subject matter (design phase only), and part-time art/graphics and editing people (early production phase only).

The seven-step procedure described below fits neatly into typical instructional development models. It describes the content analysis, methods selection, and development phases of such models. Assuming that the experienced teacher has indeed taught the desired subject matter to a representative sample of the target student population, then the data that would need to be collected during the learner analysis phase of most ID models will already be available in the experienced teacher's head and can be accessed by the designer as they are needed. Similar data for needs/goals would also be available. However, if such an experienced person is not available, then standard needs/goals analysis (see, e.g., Kaufman, 1972) and learner analysis (see, e.g., Davis, Alexander, & Yelon, 1974) should be performed prior to this seven-step procedure. Finally, it is always wise to conduct a formative evaluation and revision upon completion of this procedure, even though the firm foundation of the procedure in validated principles of instruction should greatly reduce the need for revision.

The seven-step procedure for designing and developing a textbook according to Elaboration Theory is summarized in Figure 4.1. Each of these steps is described in detail below.

1. Select and Sequence the Organizing Content Ideas.

There are three parts to this step:

1.1 Select the Kinds of Organizing Content Ideas.

This step requires the designer to help the experienced teacher to pick, based on the goals of the instruction, one of the three major ways of organizing the subject matter that is to be taught: a conceptual organization, a procedural organization, or a theoretical organization. This simply entails checking to see whether, on the basis of the general purpose of instruction, the emphasis should be on learning (a) concepts, which represent the "what" of any subject matter, (b) procedures, which describe the "how to" of any subject matter, and (c) principles, which represent the "why" (e.g., causes and effects) of any subject matter.

A concept is a set of objects, events, or ideas that share certain characteristics. A principle is a change relationship, usually a

Design and Development Procedure

1. *Select and sequence the organizing content ideas.*
   - 1.1 Select the kinds of organizing content ideas.
   - 1.2 List all of the important organizing content ideas.
   - 1.3 Arrange the organizing content ideas into an elaborative sequence and group into chapters.
   - 1.4 Allocate organizing content to chapters.

2. *Select the supporting content for each chapter, and sequence all content within each chapter.*
   - 2.1 List all of the important supporting content ideas for each chapter.
   - 2.2 Sequence both the organizing and supporting content within each chapter.

3. *Select strategies for relating new knowledge to prior student knowledge.*
   - 3.1 Decide what within-chapter synthesizers to include and where.
   - 3.2 Decide what cumulative synthesizers to include and where.
   - 3.3 Decide what student experiences can be used as instances.
   - 3.4 Decide what analogies to include and where.
   - 3.5 Decide what motivational components to include and where.

4. *Select the review strategies.*
   - 4.1 Decide which content ideas should be included in the within-chapter reviews.
   - 4.2 Decide where to put cumulative reviews and what to put in them.

5. *Select micro strategies for each idea.*
   - 5.1 Select the appropriate micro model for each idea or fact.
   - 5.2 Decide on the appropriate level of richness for that model.
   - 5.3 Write the test items and the primary and secondary strategy components for each idea.

6. *Write the remaining strategy components.*
   - 6.1 Write the integrative test items.
   - 6.2 Write the synthesizers.
   - 6.3 Write the reviews.
   - 6.4 Write the analogies.
   - 6.5 Write any remaining motivational components.

7. *Decide how to format all of the instruction.*
   - 7.1 Separate and label all ideas and strategy components.
   - 7.2 Format other aspects of the instruction.

Figure 4.1. A procedure for developing a textbook so as to implement the elaboration theory and the component display theory.

cause-and-effect relationship. And a procedure (or technique, method, skill) is an ordered set of actions for achieving a predetermined goal. So, in this step, to make the decision as to which type of organizing content ideas to use, the purpose of the course must be classified as to whether its emphasis is primarily on understanding the "whats" (i.e., the concepts), the "whys" (i.e., the principles), or the "hows" (i.e., the procedures) of the subject matter area.

To the best of our knowledge, *all* subjects include all three types of content, and therefore *all* subjects can have an elaborative sequence that is based on *any* of these three content types. For instance, the goals of a course in English Composition might emphasize knowing concepts: different kinds of compositions and the various parts of compositions (important elements which make up a good composition). Or, they might emphasize knowing procedures: how to write good composition. Or, they might emphasize knowing principles: ways in which certain factors influence the effects or quality of a composition. It is difficult to conceive of a course that is concerned with only one of these three types of knowledge. However, even when all three types of content are important, the goals of the course usually provide sufficient basis for identifying one type of content which should receive primary emphasis. Once one of the three types of content has been selected as most important, then that type (concepts, principles, or procedures) becomes the "organizing content" whose elaborative sequencing provides the "skeleton" of the textbook. The other two types of content are then added in to "embellish" the skeleton wherever they are necessary and appropriate. Due to their supporting role, they are referred to as "supporting content."

This step is an extension of, and is based on, goal analysis.

1.2 List All of the Important Organizing Content Ideas.

This step requires a teacher (possibly with a subject matter expert's help) to identify and list all of the organizing content (either concepts, procedures, or principles) that the student needs to learn. To be able to get effective outcomes from this step, the

teacher should be made explicitly aware that the particular type of organizing content that was selected in Step 1.1 has structure (i.e., interrelationships). For the *conceptual organization,* the teacher should be aware of the notion of super/co/subordinate relationships among concepts and the notions of "parts" and "kinds" varieties of those relationships. The teacher should develop those structures to make sure that no important concepts have been overlooked. Also, those structures will be considered in a later step for possible use in teaching those relationships. For the *procedural organization,* the teacher should be aware of the notions of procedural prerequisite relationships and procedural decision relationships. The teacher should make sure that no important steps or branches (in those structures) have been overlooked. For the *theoretical organization,* the teacher should make sure that no important causal relationships have been overlooked. These kinds of relationships are described in more detail in Reigeluth, Merrill, & Bunderson (1978); Reigeluth, Merrill, Wilson, & Spiller (1980); and Reigeluth & Stein (in press).

For a general illustration of the results of this step, see Figure 4.2. This step is a form of task or content analysis and description.

Ideas: A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z.

Figure 4.2. Results of step 1.2. Each letter represents a different organizing content idea, such that for a theoretical organization each letter represents a specific principle which should be taught in order to achieve the course goals.

1.3 Arrange the Organizing Content Ideas into an Elaborative Sequence and Group into Chapters.

This step prescribes that the organizing content be systematically analyzed to determine which aspect(s) of it will be presented in the first chapter and which aspects will be presented in subsequent levels of detail. The first chapter should *epitomize* all the organizing content—that is, it should represent the most general, simple, and/or fundamental aspects of all the organizing content.

For example, for a theoretical organization, this step requires

identifying the most important, fundamental principle (or two) from the theoretical content that is to be taught. To identify this principle, there are two rules of thumb. One is to ask the teacher to decide which principle he or she would teach if *only one* could be taught. The other is to have the teacher arrange the principles in the chronological order in which they were discovered, historically. If this one principle is as much as a student can learn at the application level in one chapter (including all supporting content for that principle—which has not been identified yet), then all other principles should be presented in later chapters (i.e., elaborations).

In order to allocate the remaining organizing content to later chapters, the teacher should decide (with the help of the subject matter expert), what is the next most general, simple, and/or fundamental aspects of all the organizing content. For example, for a theoretical organization, the teacher (with the help of the subject matter expert) would identify the next most important principle (or two). Again, the two rules of thumb are helpful: ask the teacher which of the remaining principles he or she would teach if only one more could be included, or identify which principle was discovered next, historically.

This sequencing procedure is continued until all the organizing content has been allocated to chapters. The sequencing procedure is a bit different for the other two organizations: procedural and conceptual. For detailed descriptions of each, see Reigeluth & Rodgers (1980) and Reigeluth & Darwazeh (1981), respectively.

The result of this step is the design of the "skeleton" of the instruction, which was developed on the basis of epitomizing and elaborating on a single type of content (see Figure 4.3 for a pseudo-example). Carefully following this process arranges the organizing content ideas into an elaborative sequence.

1.4 Allocate Organizing Content to Chapters.

This step helps the teacher and the instructional designer to allocate material to chapters. To do this, there are three considerations: (a) sequence considerations, (b) grouping considerations, and (c) size considerations.

Level	Organizing Content Ideas	
0	G, M	(most general/simple)
1	C, D, F, . . . X, Z	
2	A, B, . . . S, U	
3	E, H, K, . . . W, Y	(most detailed, complex)

Figure 4.3. Results of step 1.3. For a theoretical organization, G and M would represent such fundamental/simple principles as the law of supply and demand in economics and Ohm's law in electronics.

Sequence considerations prescribe that instructional material should be organized in levels that elaborate on each other. General or simple material should always be presented before detailed or complex materials. Sequencing within each level is based on how *facilitative* and *familiar* the material is: ideas which contribute most to understanding the organizing content should be presented first, and ideas which are more familiar should precede not-so-familiar material.

Relatedness is an important factor for *grouping considerations*, which prescribe that those ideas which are most closely related to each other should be presented together.

Size considerations depend mostly on the optimal frequency of synthesis and review. For example, if a chapter is too large, then it will be difficult for the students to remember the material in the end-of-chapter review, and it will be difficult for them to interrelate the material in the end-of-chapter synthesizer. The optimal size is likely to vary depending on the difficulty level of the content and the ability level and related experiences of the

Chapter	1	2	3	. . . .	19	20
Organizing Content Ideas	G, M	F, T, X	C, N		E, W	H, K, Y

Figure 4.4. Results of step 1.4.

students. The number of organizing content ideas and the amount of supporting content per organizing content idea can both be varied to adjust the size of the chapter. Chapter size can always be adjusted up or down later, if necessary, but such will increase the length and expense of the development effort. Hence, estimation of optimal size should be as accurate as possible at this point. Figure 4.4 illustrates the nature of the results of this step. This step is a part of the design process, and more specifically is a part of sequence design.

2. Select the Supporting Content for Each Chapter, and Sequence All Content Within Each Chapter.

2.1 List All of the Important Supporting Content Ideas for Each Chapter.

This step embellishes the "skeleton" by adding other types of content which are important for achieving the course's goals. *Supporting content* is material that is highly related to the organizing content. It includes: (1) the other three kinds of content (e.g., concepts, procedures, and facts when principles are the organizing content) and (2) the learning prerequisites for all other content selected.

Conceptual supporting content specifies useful super/co/sub-ordinate contextual knowledge that relates to the organizing content; *procedural supporting content* specifies useful procedural knowledge that relates to the organizing content; and *theoretical supporting content* specifies explanatory underlying processes or

useful change relationships that are related to the organizing content (Reigeluth & Merrill, 1979; Reigeluth, Merrill, Wilson, & Spiller, 1980).

Conceptual organizations are often supported by (additional) conceptual supporting content; procedural organizations are often supported by conceptual supporting content (concept classification is an important part of most procedures—hence the usefulness of showing coordinate relationships and sometimes even super/subordinate relationships); and theoretical organizations are often supported both by procedural supporting content (to teach an efficient way to implement a principle) and by conceptual supporting content. Therefore, except for conceptual structures, an organization structure will usually not have the same kind of supporting structure.

For each chapter, you should identify all the important supporting content for its organizing content, including all unmastered learning prerequisites for both organizing and supporting content. Do not include any supporting content unless it is necessary for, or otherwise highly related to, that chapter's organizing content, because supporting content should be added onto the "skeleton" at the *latest* appropriate point in the instruction. The process of embedding the supporting content (including learning prerequisites) into appropriate parts of the skeleton is called "nesting." For more details, see Reigeluth, Merrill, Wilson, & Spiller (1980) and Reigeluth & Stein (in press).

Typical results of this step are indicated in Figure 4.5. This step contains elements of both content analysis and instructional sequencing.

2.2 Sequence Both the Organizing and Supporting Content Within Each Chapter.

After *all* (both organizing and supporting) content has been allocated to the different chapters, this step requires establishing the best sequence of that content within each chapter. Specific guidelines for this include: (1) present a learning prerequisite immediately before the idea for which it is a prerequisite, unless several prerequisites are highly related, in which case they should

Chapter	1	2	3	...	19	20
Organizing Content Ideas	G, M	F, T, X	C, N	...	E, W	H, K, Y
Supporting Content Ideas	B_G...R_G D_M...Y_M	H_F...P_F A_T...N_T H_X...R_X	C_C...J_C F_N...M_N	...	B_E...Q_E D_W...T_W	A_H...Z_H C_K...Y_K E_Y...U_Y

Figure 4.5. Results of step 2.1. For a theoretical organization, each supporting content idea (e.g., B_G) could be a concept, a procedure, or a fact (such as the concept "supply" for the law of supply and demand).

all be presented together before their organizing ideas; (2) present non-prerequisite supporting content immediately after its organizing content, unless it is highly related to supporting content of other organizing content ideas, in which case those supporting content ideas should be presented together after all of their organizing content ideas; (3) present meaningful knowledge (e.g., a principle) before related procedural knowledge (Mayer, 1975); (4) present coordinate concepts together (in a group); and (5) rely on the teacher's intuition and experience. This is basically a sequence design step, and typical results are indicated by Figure 4.6.

3. Select Strategies for Relating New Knowledge to Prior Student Knowledge.

This step identifies ways of making new knowledge meaningful by relating new knowledge to related ideas that the student has

Chapter	Sequence of organizing and supporting content
1	B_G, F_G, H_G, G, R_G, D_M, J_M, K_M, L_M, M, T_M, Y_M
2	H_F, J_F, K_F, N_F, F, P_F, A_T, D_T, G_T, T, N_T, H_X, I_X, L_X, X, R_X
3	C_C, E_C, C, H_C, J_C, F_N, I_N, L_N, N
. . .	
19	B_E, E_E, G_E, E, K_E, Q_E, D_W, E_W, W, T_W
20	A_H, C_H, H, Z_H, C_K, D_K, E_K, K, M_K, Y_K, E_Y, F_Y, J_Y, Y, U_Y

Figure 4.6. Results of step 2.2.

already learned. Selecting the most appropriate anchorage for each kind of new knowledge (concepts, principles, or procedures) to facilitate meaningful learning is a crucial part of this step. See Reigeluth (1980) for details.

3.1 Decide What Within-Chapter Synthesizers to Include and Where.

This substep requires an instructional design expert and a teacher to decide what relationships among ideas should be taught and when. Relationships among organizing content ideas are almost always taught. For conceptual content, they take the form of kinds and parts relationships (superordinate, coordinate, and subordinate). For procedural content, they take the form of order relationships (i.e., the order in which steps should be performed) and decision criteria (i.e., the bases for deciding which steps to

use). And for theoretical relationships, they take the form of branching (multivariate) chains of causes and effects. Relationships among these three kinds of content should also usually be explicitly taught (in addition to the within-kind relationships mentioned above). For more information about these kinds of relationships and how they can be explicitly taught, see Reigeluth, Merrill, & Bunderson (1978) and Reigeluth & Stein (in press).

3.2 Decide What Cumulative Synthesizers to Include and Where.

The execution of this step is quite similar to that for the within-chapter synthesizers (Step 3.1), except that cumulative synthesizers should relate chapter specific information to ideas from other chapters. The purpose of this step is to facilitate more meaningful learning by showing context and other relationships for new ideas. This step satisfies the condition for making new knowledge meaningful by relating it to other knowledge still within the immediate content area.

3.3 Decide What Student Experiences Can Be Used as Instances.

This step requires an experienced teacher to decide what familiar instances should be presented for each idea. *Familiar instances* are defined as instances (of new content ideas) that relate to students' previous experiences. Thus, this step requires enough knowledge about the backgrounds and previous experiences of the target population of learners for the teacher to be able to identify such instances for the content being taught. Familiar instances make it easier for the learners to learn how a generality applies to instances, and they also increase retention because they provide strong, meaningful anchorage for the new knowledge (Reigeluth, 1980). Typical results of this step are illustrated in Figure 4.7.

3.4 Decide What Analogies to Include and Where.

This step requires an instructional design expert and a teacher to (1) determine when it is useful to relate new knowledge to closely-related prior knowledge that is *outside* of the subject matter content of the course, and (2) find useful analogies,

Chapter	1	2	3	...	19	20
Organizing Content Ideas	G, M	F, T, X	C, N	...	E, W	H, K, Y
Supporting Content Ideas	B_G,...R_G D_M,...T_M	H_F,...P_F A_T,...N_T H_X,...R_X	C_C,...J_C F_N,...M_N	...	B_E,...Q_E D_W,...T_W	A_H,...Z_H C_K,...Y_K E_Y,...U_Y
Within-Chapter Synthesizers	S_{1GM} S_{2GM}	S_{1FT},S_{1XT} S_{2FTX}	S_{1CN},S_{1NC} S_{2CN}	...	S_{1EW} S_{2EW}	S_{1HK} S_{2HK}, S_{2HKY} S_{3HKY}
Cumulative Synthesizers	S_{1GM}	S_{1FMG} S_{2FTGM} S_{3FTXM} S_{4FTXGM}	S_{1NX} S_{2CNX}	...	S_{1ENX} S_{2EN} S_{3WN}	S_{1YN} S_{2YKC} S_{3YWM}
Student Experiences	E_{1G}, E_{1M} E_{2M}	E_{1F},E_{1T},E_{1X} E_{2T},E_{2X}	E_{1C},E_{1N} E_{2N}	...	E_{1E}, E_{1W} E_{2E}	E_{1H}, E_{1K}, E_{1Y} $E_{,2Y}$
Analogies	A_{1G}		A_{1N}		A_{1E} A_{2E}	

Figure 4.7. Results of steps 3.1, 3.2, 3.3, and 3.4.

identify optimum ways to present or activate them, and sequence them well within each chapter. A good familiarity with the learners' backgrounds helps the attainment of this step greatly, because it facilitates selection of the most appropriate analogies for the learners, based on their previous experiences. For more about the use of analogies in the design of instruction, see Reigeluth (1980) and Reigeluth & Stein (in press).

3.5 Decide What Motivational Components to Include and Where.

This step requires the teacher to (a) identify likely motivational problems for the target student population and (b) select appropriate strategies for solving each of those problems. Keller (in press) has identified four major categories of motivational problems: (1) *interest,* which refers to whether the learner's curiosity is aroused and whether this arousal is sustained appropriately over time; (2) *relevance,* which refers to whether the learner perceives the instruction to satisfy personal needs or to help achieve personal goals; (3) *expectancy,* which refers to the learner's perceived likelihood of success and the extent to which he or she perceives success as being under his or her control, and (4) *satisfaction,* which refers to the learner's intrinsic motivations and his or her reactions to extrinsic rewards. Keller (in press) has also described a number of strategies that can be used to overcome each of these four types of motivational problems. The instructional designer should help the teacher to select the most appropriate of these or other alternative strategies.

4. Select the Review Strategies.

Elaboration Theory prescribes that instruction should have two types of systematic review: a *within-chapter review,* which summarizes all the ideas and facts presented within a single chapter, and a *cumulative review,* which summarizes the most important ideas and facts that have been presented in all chapters studied so far. Both kinds of summarizers are comprised of a concise statement of the generality, a reference example (i.e., a typical, easy-to-remember example), and diagnostic self-test practice (which is never used for assessment purposes and is always accompanied by immediate feedback) for each idea presented in the chapter.

4.1 Decide Which Content Ideas Should Be Included in the Within-Chapter Reviews.

This step requires that an instructional design expert, with the help of an experienced teacher, identify which supporting content

ideas should be included with the organizing content ideas in the within-chapter review section. All organizing content should be included, but usually it is not necessary to include all supporting content. Learning prerequisites are the kind of supporting content that is usually omitted, because the behavior associated with them is incorporated into that of the ideas for which they are prerequisite. Within-chapter reviews precede within-chapter synthesizers in order to make them maximally beneficial.

4.2 Decide Where to Put Cumulative Reviews and What to Put in Them.

This step is to ensure that the organizing content and the most important supporting content are periodically and systematically reviewed throughout the course. The frequency of such reviews depends on the difficulty and novelty of the content in relation to the ability level of the students. Cumulative reviews also precede cumulative synthesizers in order to make such synthesizers maximally beneficial.

5. Select Micro Strategies for Each Idea.

After the "macro" design steps have all been followed (selection, sequencing, synthesizing, and summarizing), it is time to design and develop the equally important instructional components that actually *teach* each idea—the "micro" strategies. Micro strategies are strategies that relate to a single idea (e.g., a single concept, principle, or procedure) or fact. Micro strategies are the domain of Merrill's Component Display Theory (Merrill, in press). The Component Display Theory's procedure for evaluating textbooks is summarized in Merrill, Reigeluth, & Faust (1979) and is described in detail in the Instructional Strategy Diagnostic Profile Training Manual (Merrill, Richards, Schmidt, & Wood, 1977).

5.1 Select the Appropriate Micro Model for Each Idea or Fact.

This step first requires the design expert and a teacher to classify the desired level of performance for the idea or fact as one of the following: (1) *remember an instance,* at which the student is required to remember a specific case—either recall or recognition

and either verbatim or paraphrased—(2) *remember a generality,* at which the student is required to remember the statement of an idea—again either recall or recognition and either verbatim or paraphrased—and (3) *use a generality,* at which the student is required to apply a generality to "new" instances—either to identify new instances or to produce new instances.

The desired level of performance for the fact or idea determines which of the Component Display Theory's three instructional models is appropriate. (An instructional model is an integrated set of strategy components for a given type of learning outcome.) For example, the most common kind of objective—"applying a generality to new instances"—is at the use-a-generality level. For this level, the Component Display Theory prescribes a model that is comprised of three major strategy components: (1) a *generality,* such as the statement of a principle or the definition of a concept; (2) *instances* of the application of that generality, such as demonstrations of the principle or examples of the concept; and (3) *practice* in applying that generality to new instances, such as solving a new problem or classifying a new example of the concept. For an objective at a different level, other strategy components are required to optimize learning.

5.2 Decide on the Appropriate Level of Richness for that Model.

This step requires an experienced teacher to decide on the appropriate level of richness for that model. This depends on the difficulty of learning the fact or idea (at the desired level of performance), given the students' general ability level and prior knowledge. In order to increase the richness for each model, the number of instances and practice items can be increased. Also, each of the major strategy components (e.g., the generality or the instances) can be embellished with secondary strategy components. The richest version of any of these models would be appropriate either for a very complex idea or very slow (or low ability) learners, or both. But for an easy idea/objective in relation to student ability, the generality alone might be enough. In this case, the student will be able to relate the generality to instances already in his or her mind by himself or herself.

It is important to keep in mind that the "use-a-generality" model may actually be richer than the "remember-a-generality" or "remember-an-instance" model, but what we are concerned with is the level of richness for a model at a single performance level. The output of this step is illustrated in Figure 4.8.

5.3 Write the Test Items and the Primary and Secondary Strategy Components for Each Idea.

This step requires the experienced teacher to write the test items and the "primary" and "secondary" strategy components that have been prescribed (by the model and its richness as selected in Step 5.2) for each idea and fact in each chapter. The *primary strategy components* are generality, instance, generality practice, and instance practice. Practice offers learners the opportunity to solve a problem and then to find out how they did on it. It is identical to an instance except that the student is now shown how it is done until he or she has tried to do it. *Secondary strategy components* include feedback, isolation, mnemonic aids, attention-focusing devices, algorithms, progression of difficulty, alternative representation forms, and more. For example, for a "remember-a-generality" level objective, the generality (a primary strategy component) can be presented along with a mnemonic device and an alternative representation form (both are secondary strategy components). Also, asking the generality in different ways (another secondary strategy component) will facilitate generality remembering (as long as verbatim recall is not required). Mnemonic devices should also be present whenever the memory load is heavy and are often included in examples and practice feedback, as well as in generalities. See Merrill (in press) and Merrill, Richards, Schmidt, & Wood (1977) for further information. See Figure 4.9 for a sample output from this step.

6. Write the Remaining Strategy Components.

This step is designed to help write the remaining instructional components. They are: integrative test items, synthesizers, reviews, analogies, and motivational components.

Chapter	1
Organizing Content Ideas	G, M
Supporting Content Ideas	$B_G, \ldots R_G$ $D_M, \ldots Y_M$
Appropriate Micro Model	$Generality_G$, $Generality_M$ $Instance_G$, $Instance_M$ $Practice_G$, $Practice_M$
Richness	Gen_G $Generality_M$ I_{1G}, I_{2G}, I_{3G} I_{1M}, I_{2M}, I_{3M} P_{1G}, P_{2G}, P_{3G} P_{1M}, P_{2M}, P_{3M}

Figure 4.8. Results of steps 5.1 and 5.2. G, M organizing content ideas are supposed to be taught at use-a-generality level.

Chapter	1
Organizing Content	G, M
Primary Strategy Components	$Generality_G$ $Instance_G$ $Practice_G$
Secondary Strategy Components	Gen_{G1}, Gen_{G2} $Ins_{1G}, Ins_{2G}, Ins_{3G}, Ins_{4G}$, (easy), I_{5G}, (difficult) $Practice_{1G}, Practice_{2G}, Practice_{3G}, Practice_{4G}, Practice_{5G}$ $Feedback_{1G}, Feedback_{2G}, Feedback_{3G}, Feedback_{4G}, Feedback_{5G}$ $Practice_{1I}, Practice_{2I}, Practice_{3I}, \ldots$ $Feedback_{1I}, Feedback_{2I}, Feedback_{3I}, \ldots$

Figure 4.9. Results of step 5.3.

6.1 Write the Integrative Test Items.

Testing should occur at the level of relationships among ideas as well as at the level of individual ideas. The relationships among specific organizing content ideas are particularly important to test.

6.2 Write the Synthesizers.

The synthesizers are written according to the specifications from Steps 3.1 and 3.2. The generality is one or more subject matter structures (Reigeluth, Merrill, & Bunderson, 1978; Reigeluth & Stein, in press) plus any explanation that facilitates understanding those structures. The instance is an integrative instance that illustrates the relationship among the ideas. And the practice is diagnostic, as self-test items which allow the student to find out whether he or she understands the relationship among the ideas.

6.3 Write the Reviews.

Have the teacher write a concise statement of the generality, a reference example for the generality, and a few self-test practice items for each idea in each chapter according to the specifications in Step 4.

6.4 Write the Analogies.

The teacher should write all analogies according to the specifications prepared in Step 3.4.

6.5 Write Any Remaining Motivational Components.

The teacher should write all motivational strategy components that have not yet been written as parts of other strategy components. In some cases, it may be necessary to modify or add to previously written components in order to implement a given motivational strategy component.

7. Decide How to Format All of the Instruction.

One purpose of formatting is to make a textbook more *attractive* and more *communicative.* Principles of message design are relevant here. Another purpose is to make explicit for the

student what the *important content* is to be learned versus what is primarily elaborative, motivational, or simply "nice to know" material. A third purpose of formatting is to facilitate *learner control* (Merrill, 1979), which allows individualization of the instruction based on learner differences. Learner control is a strategy whereby learners skip over some strategy components, refer back to earlier strategy components, and/or simply study the various strategy components in a different order. For example, a brighter student might look at a generality, think "I understand that!," and go to a hard practice item to test himself or herself. On the other hand, a slower student might spend considerable time looking at examples after studying a generality. Then he or she might look at the generality again before any practice items.

7.1 Separate and Label All Ideas and Strategy Components.

In order for a student to be able to exercise learner control easily and efficiently, each strategy component must be: (1) separated from other strategy components and other kinds of displays and (2) labeled for the student so that there is no ambiguity as to what is the main idea and what is illustration, elaboration, or clarification. For example, generalities should be labeled as such and should be separated from say, examples; practice should be labeled as such and should be separated from generalities and examples; review and feedback components should be labeled and separated, synthesis components and analogies should be separated and labeled, etc. With such separation and labeling of strategy components, brighter students will be able to skip over examples and secondary strategy components more easily and without fear of having missed something important; and slower students will find it easier to refer back to generalities, reviews, and synthesizers to compensate for the extra time they find they need to spend on examples, practice, and secondary strategy components.

Proper student use of learner control formatting requires some brief student training in (1) the nature of each strategy component, and (2) the way in which each component helps the student to learn (i.e., to overcome a different kind of learning problem).

With such knowledge, the student is well equipped to pick and choose from the "menu" of strategy components to make his or her own optimal, individualized instructional design. Here, to accommodate individual differences, *learner control over the selection of different strategy components,* rather than having different "tracks" for different types of students, is being advocated. This can be supported by two reasons; even if research shows that a certain strategy is always best for a certain type of student, (1) if the student characteristics cannot be changed—such as certain kinds of aptitude—it is important for the student to learn which strategies are best for him or her, and (2) if the student characteristics can be changed—such as poor learning strategy—it is much more important to improve that shortcoming than to provide an instructional strategy (or method) that minimizes it. For example, rather than designing "visual" instruction for some students and "verbal" instruction for others, make both representations available to all students, along with some knowledge about how to pick and choose, rather than studying everything. It is also likely that the vast majority of students are not strictly verbal or strictly visual and can therefore benefit from having both available.

7.2 Format Other Aspects of the Instruction.

This is done primarily on the basis of principles of message design. Separation and labeling of all major strategy components should be implemented, and their sequence or arrangement with respect to each other should also be designed according to principles of message design. Finally, the internal formatting of each individual component should also be done.

Motivational, clear, and easy-to-produce layout is always essential for easy, meaningful learning and good retention. No matter how instructionally useful each idea is and no matter how well-organized those instructional ideas are, they might not serve their function if they are not presented to the learner in the best possible format.

A Procedure for Evaluating Textbooks Using Elaboration Theory

1. Analyze the Organizing Content: Its Selection and Its Chapter-Level Sequencing.

1.1 Select the Kind of Organizing Content.

This step prescribes evaluating the selection of an "organization" on the basis of the goals or purpose of the instruction. It is a means to check whether or not the requirements for design/development Step 1.1 have been satisfied.

1.2 Identify the Most Important Organizing Content Ideas.

This step entails listing all important organizing content ideas that are presently discussed in the textbook.

1.3 Is All Important Organizing Content Included?

This step requires a subject matter expert and an experienced teacher to decide whether or not *all* of the important organizing content ideas listed in Step 1.2 (either concepts, principles, or procedures) have been included in the text. A subject matter expert is needed to prioritize the important organizing content ideas, and an experienced teacher (for the target population of students) is needed to identify, in consideration of time limitations for the course, a reasonable cut-off point for that prioritized list. The cut-off point is based primarily on the ability level of the students (e.g., average high school juniors) and the length of the course (e.g., one-hour meetings three times a week for 32 weeks).

1.4 Elaborative Sequence of Organizing Content and Good Chapter Allocation?

This step requires the design expert, with the help of a subject matter expert or an experienced teacher, to decide whether or not the chapters are sequenced in an elaborative way with respect to the organizing content and whether the organizing content is appropriately allocated to chapters. The resulting content distribution should satisfy sequence, grouping, and size considerations as described in design/development Step 1.4.

2. Analyze Both the Organizing and Supporting Content: Its Within-Chapter Selection and Sequencing.

2.1 No Inappropriate Organizing Content Included?

This step requires a subject matter expert or experienced teacher, by referring back to the prioritized list of organizing content ideas and its cut-off point, to decide whether or not any inappropriate organizing content has been included within each chapter.

2.2 All Important Supporting Content Included?

This step requires an experienced teacher to decide whether or not *all* of the important supporting content ideas have been included within the same chapter as the organizing content ideas which they support.

2.3 No Inappropriate Supporting Content Included?

This step requires an experienced teacher to decide whether or not any inappropriate or unimportant supporting content has been included in any chapters. This decision will depend primarily on the degree of importance and the degree of relevance of the supporting content to the organizing content.

2.4 Organizing and Supporting Content Sequenced Well?

This step requires an instructional design expert and an experienced teacher to decide whether or not the organizing content ideas and supporting content ideas are grouped appropriately, according to the guidelines in Step 2.2 of the design/development procedure.

3. Analyze the Strategies for Relating New Knowledge to Prior Student Knowledge.

3.1 Sufficient Within-Chapter Synthesis?

This step requires a design expert and a subject matter expert to determine for each chapter whether or not there is sufficient synthesis of the within-chapter content. This tells whether or not

important relationships among ideas are explicitly taught and appropriately located.

3.2 Sufficient Cumulative Synthesis?

This step requires the design expert and a subject matter expert to determine whether or not there is sufficient explicit teaching of relationships between content in one chapter and content in earlier chapters. They should also determine whether the location of such synthesizers is appropriate. Such explicit synthesis is likely to come at the end of a chapter or at the end of a unit.

3.3 Sufficient Familiar Instances?

This step requires an experienced teacher to determine whether or not there are sufficient familiar instances within each chapter. Familiar instances are examples of a concept, applications of a principle, or performance of a procedure that are closely related to the previous experience of the learner. Using familiar instances facilitates learning and increases motivation.

3.4 Sufficient Analogies?

Analogies relate new knowledge to closely-related knowledge that the student has already acquired *outside* of the subject matter content of the course. This step requires the design expert and a subject matter expert or teacher to determine whether or not sufficient analogies have been presented within each chapter.

3.5 Sufficient Motivational Components?

This step requires the design expert and teacher to determine whether or not sufficient motivational components are built into each chapter, based on the types of motivational problems that the teacher anticipates for the chapter content and the target student population (see Step 3.5 of the design/development procedure). Also, you should determine whether or not their locations are appropriate.

4. Analyze the Review Strategies.

4.1 Sufficient Within-Chapter Review?
This step requires an experienced teacher to analyze the chapter summaries to determine whether or not sufficient within-chapter review is provided.

4.2 Sufficient Cumulative Review?
This step requires an experienced teacher to analyze the unit summaries to determine whether or not sufficient cumulative review is provided.

5. Analyze the Micro Strategies for Each Idea.

5.1 Select the Appropriate Micro Model for Each Idea or Fact.
This step entails determining the appropriate micro model for each idea that is to be taught.

5.2 Select the Appropriate Richness for Each Model.
This step prescribes deciding on the appropriate richness for each model, on the basis of the difficulty of the idea that is to be taught in relation to student ability and experience.

5.3 Test Items and Primary and Secondary Strategy Components Appropriate?
This step entails determining whether or not the test items are appropriate and whether or not the optimal primary and secondary strategy components are presented in the textbook for each idea to be taught.

6. Analyze Integrative Test Items, Synthesizers, Reviews, Analogies, and Motivational Components.
This step checks to see whether or not integrative test items, synthesizers, reviews, analogies, and motivational components are all well-designed and written. Clarity and conciseness are important considerations (see design/development Step 6 for details).

7. Analyze the Formatting of All Strategy Components Analyzed Above.

7.1 Are the Ideas and Strategy Components Separated and Labeled?
This step requires a design expert to decide how well the strategy components are separated and labeled so as to facilitate learner control.

7.2 Are Other Aspects of the Formatting Appropriate?
This step requires a design expert to decide how attractive and communicative the page layout is.

A Procedure for Revising Textbooks Using Elaboration Theory

In addition to originating new text and evaluating existing text for instructional quality, instructional design theory can also be used as a basis for modifying and correcting instructionally problematic text. The following revision procedure is only used after the Elaboration Theory's evaluation procedure has been used to diagnose design problems.

For instructional materials which are found to be highly problematic with regard to all or most of the evaluation criteria (of the evaluation procedure), the optimal revision procedure is to deal with those design problems in the order that they were identified by the evaluation procedure. The necessary revisions for each problem are made by using the corresponding step of the design/development procedure.

However, if the instructional materials need revision only with regard to a few criteria, then revision should be done by using isolated parts of the design/development procedure. In this case, it is still recommended to do the revisions in the order in which the evaluation steps are listed, because otherwise you may waste time revising something which ends up being deleted altogether. For each weakness revealed by the evaluation procedure, you should find the comparable design/development step and revise the material accordingly.

After the revision procedure has been completed, a final check is recommended. You should go through the evaluation profile (the results of the evaluation procedure) once more to make sure that you have not missed any important points to be revised. If you have missed any such points, go to the appropriate steps of the design/development procedure to make required revisions. When you are finished with this final check, the revision procedure is concluded.

Conclusion

Instructional theory is at best in its early adolescence at the present time. It is only very recently that investigators have begun to build individual strategy components into optimal models of instruction for different goals and different conditions (e.g., different kinds of students and different kinds of subject matter). Much work remains to be done before instructional theory will realize its potential contribution to improving textbooks. Using ideas such as those presented in this chapter is likely to yield as much useful information as formal research, but there is clearly a need for much of both. It is our hope that this chapter will contribute in some small way to encouraging both kinds of endeavors to improve our knowledge about how to write effective, efficient, and appealing textbooks.

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5.

Brain Functions During Learning: Implications for Text Design

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During the past ten years much has been written about the brain as "the last frontier" for scientific investigation; and indeed the number of investigators in this area has, by some estimates, doubled within the past five years alone. The resultant reports of scientific studies have been summarized and popularized by educators and, at least in some instances, misinterpreted. This chapter will focus on reports from basic scientists in the areas of neurobiology, neurobiochemistry, and physiology. Implications are suggested for the use of this information in the design of textual materials. These implications are in many instances untested hypotheses; and the reader is free to draw separate, conflicting conclusions, with the only caveat being that the original research reports should be read prior to generating those hypotheses.

Applied research regarding brain function, learning, and memory in the classroom is just beginning in this country, although classroom results have been reported in European journals since the mid-1960's. While it is still too early to make hard and fast judgments, the *implications* of results of basic science studies seem clear enough. At the very least, research on textual design may be stimulated in new areas of investigation to confirm or deny the educational importance of the presented research.

This chapter is divided into seven sections: (1) short-term memory and its pitfalls; (2) long-term memory storage; (3) left-right brain functions and holographic memory; (4) the triune