IN ORDER TO LEARN

How the Sequence of Topics Influences Learning

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Chapter 2

Order, First Step to Mastery: An Introduction to Sequencing in Instructional Design

Charles M. Reigeluth

To create quality instruction, you need to make two types of decisions well: what to teach and how to teach it. The purpose of this chapter is to describe an instructional design perspective on how to sequence instruction (a part of how to teach it). However, scope (a part of what to teach) is also included because it interacts greatly with ordering. This chapter provides an entry point for interested readers into the instructional design literature and introduces some of the issues from this field. It shows how sequence effects relate to instruction, and it provides some introduction to the context where order matters.

THE ROLE OF SCOPE AND SEQUENCE WITHIN INSTRUCTION

Where does the ordering of content fit within the broader process of creating quality instruction? In considering this question, we would do well to think of the instructional process as a series of decisions, which are shown as rows in Table 2.1. Each of those decisions requires that some analysis activities be conducted to collect the information required to make the decision, such as needs analysis for intervention decisions. Each also requires some synthesis activities and should be followed by formative evaluation activities to make sure the decision was a good one or to improve it before it becomes expensive to change. And each one should be accompanied by several decisions and activities on organizational change processes that will facilitate the implementation and effectiveness of the instruction.

Therefore, the process of creating quality instruction, called instructional systems design (ISD), can be viewed as a series of cycles—analysis, synthesis, evaluation, change (ASEC)—for each decision shown in Table 2.1. This view is taken from Reigeluth (2006).

This chapter provides a synthesis and evaluation of scope and sequence decisions for instruction. Table 2.1 shows how these decisions fit with other choices in ISD. They are explained in more detail in my forthcoming book, but I explain here a few of the most important ones for understanding the role and use of scope and order effects in instructional design.

Intervention Decisions [1]

Intervention decisions have to do with broader reasons for considering instruction at all. Intervention decisions can take a partial or a total systemic approach.

If you take a *partial systemic approach*, you identify one or more of the organization's performance problems, you analyze *all* the causes of, and potential solutions to, those problems, and you select the best set of solutions. These may include changes in the incentive systems, equipment, work processes, and/or

TABLE 2.1. Major Decisions in the Instructional Systems Design Process

Change	*Analysis*	*Synthesis*	*Evaluation*	*Organizational Change*
1. Intervention decisions	1.1	1.2	1.3	1.4
Instructional Design	*Analysis*	*Synthesis*	*Evaluation*	*Organizational Change*
2. Fuzzy vision of ends and means	2.1	2.2	2.3	2.4
3. Scope and sequence decisions	3.1	3.2	3.3	3.4
4. Decisions about what instruction to select and what to develop	4.1	4.2	4.3	4.4
5. Approach decisions	5.1	5.2	5.3	5.4
6. Tactical decisions	6.1	6.2	6.3	6.4
7. Media selection decisions	7.1	7.2	7.3	7.4
8. Media utilization decisions	8.1	8.2	8.3	8.4
Development	*Plan*	*Do*	*Check*	*Organizational Change*
9. Prototype development	9.1	9.2	9.3	9.4
10. Mass production of instruction	10.1	10.2	10.3	10.4
Evaluation and Change	*Analysis*	*Design/ Development*	*Evaluation*	*Organizational Change*
11. Evaluation of worth and value	11.1	11.2	11.3	11.4
12. Implementation, adoption, organizational change	12.1	12.2	12.3	12.4

management systems—as well as the knowledge and skills—of the learners (students or trainees). For Activity 1, you just *plan* the set of interventions that will best solve your problem. Implementation of those plans comes later.

If you take a *total systemic approach*, you will strive to be a "learning organization" (Senge, 1990), which means you will start by looking outside the organization to the relationships between the organization and its customers.[1] How well is the organization meeting its customers' needs? How are their needs changing? Do they (or other potential customers) have other needs that are not being met well and that you might be able to respond to? For Activity 1, you just *plan* the set of interventions that will best respond to those needs. Implementation of those plans comes later.

Regardless of which approach you take, you proceed with the ISD process only if one of your solutions is to advance knowledge or skills.

Scope Decisions and Sequence Decisions [3]

Scope decisions are choices about what to teach—the nature of the content.[2] They require decisions about what the learner needs and/or wants to learn. Sequence decisions are concerned with how to *group* and *order* the content. They entail decisions about how to break up the content into chunks that will not exceed the learners' cognitive load capacity (Sweller, this volume, Chapter 15), how to order those chunks, and how to sequence the content within each chunk. How to make these decisions is the focus of this chapter.

Decisions About What Instruction to Select and What to Develop [4]

Regardless of what you need to teach or learn, chances are that someone has already developed instruction

1. I use the term "customers" in the broader sense of all those the organization serves, including the learners.
2. I use the term "content" to refer to everything that comes under "what to teach." It therefore includes whatever tasks you might teach, as well as whatever knowledge, and the term "content analysis" includes "task analysis."

for it. You can often save yourself a lot of time and money by obtaining these existing materials. To do so, you first must identify the alternatives (existing instruction), evaluate their quality in relation to your needs and conditions, procure the most cost-effective alternative, and make whatever revisions are cost effective. The revision process entails making many of the remaining decisions (decisions 5–10 in Table 2.1). In most cases, you will need to develop some new instruction in addition to revising existing materials. The order of content can be important for revising and using existing resources.

Approach Decisions [5]

The systems concept of equifinality tells us that there is usually more than one way to accomplish any given end. Different teachers or trainers often use very different approaches to teach the same content, including various kinds of expository instruction (such as lectures, tutorials, drills, and activities), diverse kinds of inquiry or discovery instruction (such as problem-based learning and Socratic dialogue), and different types of experiential learning (such as problem-based learning, project-based learning, and simulation). A variety of approaches may also entail teaching individual students, small groups or teams, or large groups. Decisions about one's approach (5.1 in Table 2.1) will impact much of the rest of the design of the instruction and should therefore be made early in the ISD process.

Tactical Decisions [6]

As approaches are strategic decisions, their effective implementation requires tactical decisions. Different types of learning are fostered by different types of instructional tactics, regardless of the approach you use. For example, it is difficult to acquire a skill without practicing it and receiving feedback. Demonstrations (examples) and explanations (generalities) can be very helpful as well. On the other hand, understanding is best fostered by linking new knowledge with the learner's related prior knowledge. This may entail the use of tactics such as analogies, comparison and contrast, context, and relating to the learner's experiential knowledge. Memorization and higher-order thinking skills are other types of learning that require very different kinds of instructional tactics. (See Leshin, Pollock, & Reigeluth, 1992, for an in-depth treatment of instructional tactics.)

Evaluation of Worth and Value [11]

Summative evaluation is almost always worthwhile, as long as it addresses the impact on the overall mission or purpose of the organization. At the very least, it should indicate whether this particular ISD project was worthwhile. Ideally, it will also help the organization to decide whether to continue to invest in ISD projects. It may also yield information about how to increase the worth and value of this particular instructional system and of ISD projects in general for the organization.

Given this overview of the ISD process, this chapter focuses on the analysis and synthesis activities for decisions on scope and sequence of instruction (boxes 3.1 and 3.2 in Table 2.1). The following section explores definitions of scope and sequence, the reasons (or times) they are and are not important, and general issues relating to each. After that I review and explain some important sequencing strategies.

BASICS OF SCOPE AND SEQUENCE

Instructional design defines sequence effects slightly differently than the definition in Chapter 1, particularly because it examines the role and context of scope. This section presents a somewhat more contextualized definition of sequence effects.

Scope decisions are decisions about what to teach—the nature of the content, including tasks, skills, and higher-order thinking skills. They require us to make choices about what the learner needs and/or wants to learn. Sequence decisions are concerned with how to *group* and *order* the content. You cannot order the content without creating some kind of groupings to be ordered, and different kinds of sequences require different types of groupings. They require several types of decisions regarding size of groupings, contents of groupings, order within groupings, and the order of groupings (Figure 2.1). These all influence the quality of the instruction: its effectiveness, efficiency, and appeal.

Does Scope Make a Difference?

Setting the scope of instruction identifies the content that will be ordered. If you are in a training department for any of the three primary sectors (private, public, or nonprofit), the employees or customers need certain skills and knowledge to perform well. If you do

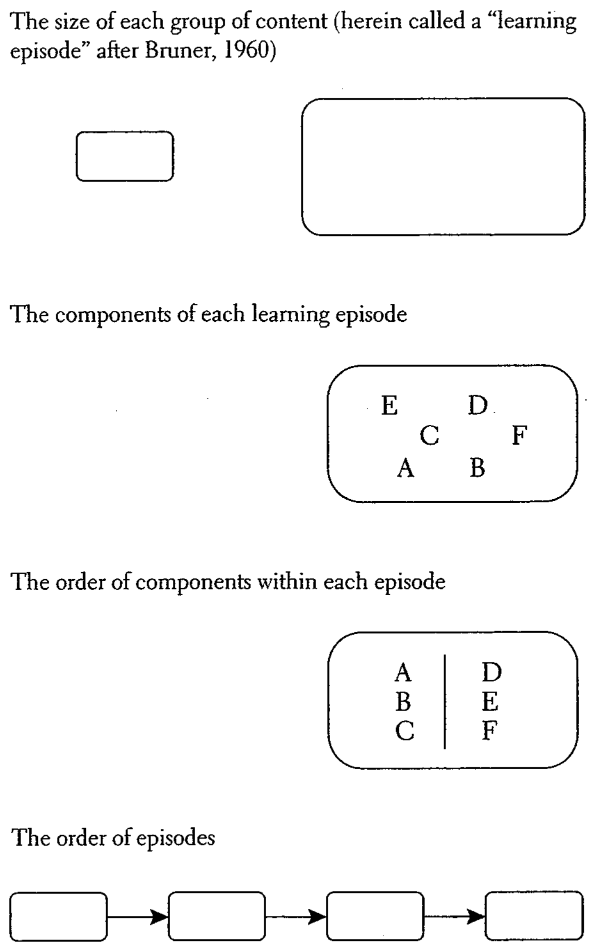


FIGURE 2.1. Types of decisions for sequencing content.

not teach what they need, it does not matter how good the remaining aspects of the instruction are.

However, a K–12 or higher education context is very different in that the needs are much less clear and depend largely on values. Furthermore, students have interests that may be unrelated to the values of the community and the parents. And the benefits of the instruction may not become apparent until many years later. All of these factors make it much more difficult to say whether scope makes a difference or, perhaps more accurately, what kinds of difference scope makes. Clearly, the differences scope makes vary from one student to another and from one "stakeholder" to another in the educational system. (Stakeholders are all those who have a stake in the particular educational system, such as parents, employers, taxpayers, students, and social service agencies). But ask any student or any stakeholder whether what is taught makes a difference to them, and you are almost certain to get a resounding "Yes!" (Guidance for setting the scope of instruction is discussed later in this chapter.)

Technology is evolving to the point where we can create flexible, computer-based, learning tools that students can use—while they are learning—to create or modify their own instruction. This is one way that scope and sequence interact. Furthermore, with team-based learning, different teams can pursue different interests, with the teacher assuming the role of a coach or guide steering them to appropriate resources, many of which utilize advanced technologies. This means that students will be able to make decisions about what to learn (and even about how to learn it) while the instruction is in progress. Thus, sequencing decisions may need to be done on the fly. The later chapters by VanLehn, by Swaak and de Jong, and by Scheiter and Gerjets provide examples of learners and instructors doing this.

Just as the business world has been evolving from standardization to customization, a systemic content selection process is likely to reveal that students should not learn *all* the same things. Osin and Lesgold (1996) talk about "defining a required common curriculum and supporting additional student choices" (p. 642). The Indiana Curriculum Advisory Council (1991) came to a similar conclusion after much input from many stakeholder groups:

> The intent of 21st Century Schooling is to invent schools which give each child access to the conditions which make possible learning achievement to the limits of individual ability. . . . Required will be a 180 degree shift in Indiana's educational policy: from a narrow, rigid focus on covering isolated content, to a sensitive, responsive focus on each student. (p. 1)

Therefore, much of the content selection that is now done by a teacher (or curriculum committee) for a group of learners well ahead of the actual instruction could soon be done during the instruction as multimedia systems (and the teacher) continuously collect information from individual learners and/or small teams of learners and use that information to present an array of sound alternatives to the students, both about what to learn next and how to learn it. The learners' decisions will, in all likelihood, be tempered by collaborative input from the teacher and parents. Doing this well will be assisted by understanding order or sequence effects. However, I hasten to reemphasize that there will likely be some content that the stakeholders will believe all students should learn (or that students with certain interests should learn), and a stakeholder-based selection process, founded in the user-design approach (Banathy, 1996; Carr-Chellman & Savoy, 2003; Carr-Chellman, in press), should be created to help make that decision.

Does Sequencing Make a Difference?

This is a very common question, but it is the wrong one! The issue, as with most instructional strategies, is not *whether* it makes a difference but *when* it makes a difference and when it does not. The impact of sequencing depends upon two major factors: the strength of the relationships among the topics and the size of the course of instruction.

Sequencing is important only when there is a strong relationship among the topics of the course. If a course is composed of several unrelated topics, such as word processing, computer graphics, and electronic spreadsheets, the order for teaching the topics is not likely to make any difference because there are no important relationships among them. On the other hand, when there is a strong relationship, the sequence used will influence how well both the relationship and content are learned. For example, there is an important relationship between the analysis and design phases in the ISD process. Some sequences for teaching ISD take a fragmented approach that makes it difficult to learn the relationship and understand the content, whereas other sequences facilitate such learning.

Second, if a strong relationship exists among the topics, then as the size of the course increases, so does the importance of sequencing. When the content requires more than about an hour to learn, sequencing is likely to begin to make a significant difference, albeit a small one, in the learners' ability to master it because most learners will have a difficult time organizing so much content logically and meaningfully if it is poorly sequenced. However, when the content to be learned is minimal (e.g., less than about an hour), the human mind can compensate for weaknesses in the sequence. This type of compensation may be occurring in the studies reported in VanLehn's and in Swaak and de Jong's chapters.

Types of Sequencing Strategies: Relationships Are the Key

The importance of relationships in the content is twofold. As I have just mentioned, if no relationships exist, then sequencing does not matter. But the second point is that each method of sequencing is based upon a single type of relationship. For instance, a historical sequence is based upon chronological relationships—a sequence is devised that follows the actual order of events. A procedural sequence, the most common pattern of sequencing in training, is based upon the relationship of the "order of performance" of the steps in the procedure. A hierarchical sequence is based upon the relationship of learning prerequisites among the various skills and subskills that compose a task. Moreover, the "simplifying conditions" sequence (described later) is based upon the relationship of the degree of complexity of different versions of a complex task.

Furthermore, when several topics need to be taught, two basic patterns of sequencing can be used that are fundamentally different: topical and spiral (see Figure 2.2).

Topical Sequencing

In topical sequencing, a topic (or task) is taught to whatever depth of understanding (or competence) is required before the next one is taught. There are both advantages and disadvantages of topical sequencing. Learners can concentrate on one topic or task for in-depth learning without frequently skipping to new ones. In addition, hands-on materials and other resources are all used in one block of time, rather than being used at different points scattered over several months or a year. However, once the class (or team or individual) moves on to a new topic or task, the first one can easily be forgotten. The learners do not gain a perception of what the whole subject domain is like

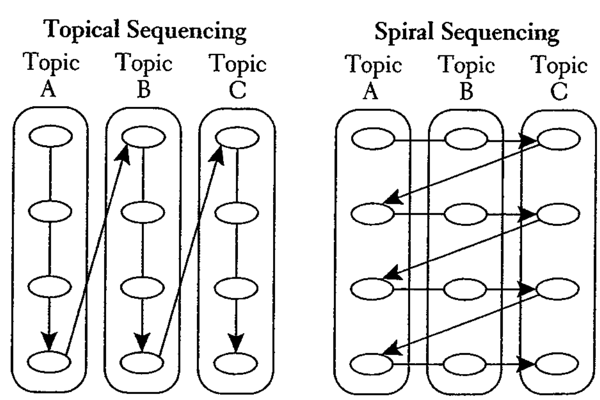


FIGURE 2.2. Topical and spiral sequencing (from Reigeluth & Kim, 1995.)

until they reach the end of the course or curriculum. The weaknesses of topical sequencing can be compensated for, to some extent, by incorporating tactics for overview, review, and synthesis.

Spiral Sequencing

In spiral sequencing, the learners master a topic or task gradually in several passes. They learn the basics of one topic or task, then another, and another, and so on before returning to learn each one in greater depth. They spiral back through all of the topics or tasks, learning each one in greater depth with each pass until the necessary depth is reached for all of them.

The main advantage of spiral sequencing is its built-in synthesis and review. The interrelationships among topics or tasks may be learned more easily using the spiral approach because it allows similar aspects of the various topics or tasks to be learned close in time to each other. Furthermore, cycling back to learn an earlier topic or task in greater depth provides a periodic review of the earlier one. On the other hand, the main disadvantage of spiral sequencing is disruption. Once a particular topic or task has been started, learners get into a particular frame of mind (schema). Frequently switching disrupts their thought development. In addition, switching may disrupt the efficient management of material resources needed as they progress from one topic or task to the next. The chapters exploring transfer (e.g., VanLehn, Scheiter, and Gerjets) point out some of the complexities.

Which One Is Best?

Again, this is a very common question, but, as before, it is the wrong one. The issue is not *which* pattern of sequencing is best but *when* each is best. Furthermore, in reality neither topical nor spiral sequencing exists in a pure form. In an extreme case, spiral sequencing could entail presenting only one sentence on each topic or task before spiraling back to make another pass on a deeper level. The real issue lies in how deep a slice a teacher or learner makes on one topic or task before going on to another. Rather than thinking of spiral and topical sequencing as two separate categories, it is useful to think of them as the two end points on a continuum. The instructional designer's (or the learner's) decision, then, is where on the continuum to be for any given training program or curriculum.

SOME MAJOR SEQUENCING STRATEGIES: UNDERSTANDING THE THEORIES

This section describes some of the major sequencing strategies: procedural, hierarchical, simplifying conditions, conceptual elaboration, and theoretical elaboration. The book (Reigeluth, in preparation) describes how to design and conduct analyses for each of these kinds of instructional sequences. I begin with the hierarchical sequence because it is used by all of the others. It is important to understand the procedural sequence before the Simplifying Conditions Method (SCM) sequence for the same reason.

Hierarchical Sequence

Robert Gagné developed the hierarchical sequence for teaching "intellectual skills" in the cognitive domain. Intellectual skills are domain-dependent skills (those that pertain to a single subject area, or domain) and are contrasted with "cognitive strategies," which are domain-independent skills (ones that can be applied across domains, such as critical thinking skills).

The hierarchical sequence is based on the observation that a skill is made up of simpler "component skills" that you must learn before you can learn the larger, more complex skill of which they are a part (the model in Chapter 5, for example, illustrates this). For example, you must learn to multiply and subtract whole numbers before you can learn how to do long division (see Figure 2.3). Thus the sequencing strategy is basically that, if one skill has to be learned before another can be learned, teach it first. It is that simple—in theory—but not so easy in practice.

How do you determine what the prerequisite skills are? This is the purpose of a hierarchical task analysis. To help with that task, Gagné has identified a variety of kinds of skills that are prerequisites for one another (Figure 2.4).

The skill for a discrimination is the ability to tell the difference between "stimuli that differ from one another along one or more physical dimensions" (Gagné, Briggs, & Wager, 1992, p. 56). For example, one particular discrimination is the ability to tell the difference between a triangle and a rectangle. It does not require being able to label either shape. It differs from memorization (or Gagné's "verbal information") in that it requires some degree of generalization, such

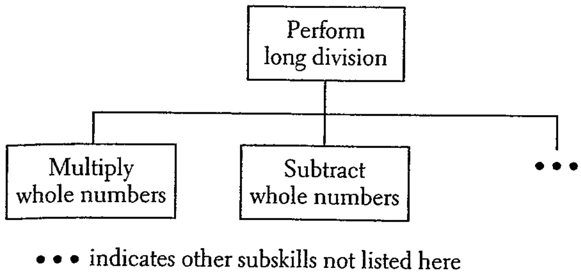


FIGURE 2.3. A learning hierarchy in which the lower skills must be learned before the higher skills can be learned. (The entire hierarchy is not shown.)

as being able to tell the difference between any triangle and any rectangle. The conclusion of the performance of this skill is usually saying whether two things are the same or different.

The skill for a concrete concept is the ability "to identify a stimulus as a member of a class having [an *observable* property] in common, even though such stimuli may otherwise differ from each other markedly" (Gagné, Briggs, & Wager, 1992, p. 57). For example, one particular such skill is the ability to identify any triangle as a triangle. Classifying a concrete concept differs from making a discrimination in that it requires naming or otherwise identifying a particular instance as belonging to a class, rather than just being able to say that the instance is different from, or the same as, something else. The conclusion of the performance of this skill is usually indicating whether something belongs to a given class of things.

The skill for a defined concept is the ability to identify a stimulus as a member of a class having a *definable* property in common, even though such stimuli may otherwise differ markedly from each other. Defined concepts include objects (such as a "pen"), events (such as a "fight"), and ideas (such as "justice"). For example, one particular such skill is the ability to identify any polygon as a polygon. The differences between defined and concrete concepts are highlighted in the definition here. Defined concepts all have definitions, whereas many (but not all) concrete concepts do not (like the musical note C). All concrete concepts are tangible in some way (they can be touched, seen, heard, etc.). However, the distinction between defined and concrete concepts is not always easy to make. According to Gagné, Briggs, and Wager (1992),

> Some defined concepts have corresponding concrete concepts that carry the same name and possess certain features in common. For example, many young children learn the basic shape of a triangle as a concrete concept. Not until much later in studying geometry do they encounter the defined concept of triangle. . . . The concrete and defined meanings of *triangle* are not exactly the same, yet they overlap considerably. (p. 60)

It seems that the difference is "in the eye of the learner," as it were. If the skill is learned by generalizing from instances and the learner does not consciously use a definition to guide the performance of the skill, then it is a concrete concept for that learner. But if the learner uses a definition (either invented by, or given to, the learner) to guide the performance of the skill, then it is a defined concept for that person.[3] As with concrete concepts, the conclusion of the performance of this skill is usually indicating whether a specific instance belongs to a given class of instances. Most of the model chapters use rules (which are further explained in the chapter by Nerb, Ritter, and Langley), and several of the application chapters illustrate the learning of rules.

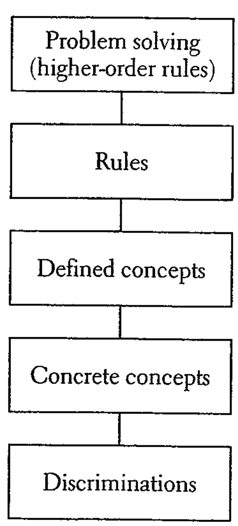


FIGURE 2.4. A hierarchy of intellectual skills (from Gagné, 1965). Reprinted with permission of Wadsworth, a division of Thompson Learning.

3. For instructional purposes, I do not see much value in the distinction between concrete and defined concepts, except that you cannot use a definition to help someone learn a concrete concept.

The skill for a rule is the ability to consciously or subconsciously apply the rule to new situations. A rule is "a *class* of relationships among *classes* of objects and events" (Gagné, Briggs, & Wager, 1992, p. 61). I find it useful to think in terms of two major kinds of rules: procedural rules and heuristic rules. A *procedural rule* is a set of steps for accomplishing a goal, such as the rule for multiplying fractions (first, multiply the numerators, then multiply the denominators, then . . .). A *heuristic rule* is a principle or a guideline, such as the law of supply and demand (an increase in price will cause a decrease in the quantity demanded and an increase in the quantity supplied, while a decrease in price . . .).

So what is the difference between a rule and a defined concept? As Gagné, Briggs, and Wager (1992) put it, "a defined concept is a particular type of rule whose purpose it is to classify objects and events; it is a *classifying rule*" (p. 62). A classifying rule may be either procedural (for well-defined concepts like "triangle") or heuristic (for "fuzzy" concepts like "justice"). Very often people are not consciously aware of the rules they use—they (particularly experts) cannot actually state the rules that govern their thinking and behavior. This is what Polanyi (1983) referred to as tacit, as opposed to explicit, knowledge. And this is why experts are often not the best teachers of novices. The conclusion of the performance of this skill is usually the attainment of a specific goal for a specific situation.

The skill for a higher-order rule is the ability to consciously or subconsciously apply a higher-order rule to new situations. A higher-order rule is "a complex combination of simpler rules" (Gagné, Briggs, & Wager, 1992, p. 63). Such rules may also be procedural or heuristic. The act of inventing a higher-order rule is called *problem solving*, but once it is invented by, or given to, the learner, then it becomes an act of rule using (or more accurately, higher-order rule using) rather than problem solving. The difference between a higher-order rule and a rule is simply one of complexity: A higher-order rule is a rule that combines several simpler rules. An example of problem solving is figuring out the area of an irregularly shaped figure for the first time. The conclusion of the performance of this skill is usually the attainment of a specific goal for a specific situation.

The hierarchical arrangement of these skills (shown in Figure 2.3) helps you to figure out what prerequisites any given skill might have, but it can also be misleading because it is not true that a skill on one level has prerequisites *only* on the next lower level. In fact, any given skill usually has many levels of prerequisites on the very same level of Gagné's hierarchy. For example, the skills on both levels 1 and 2 in Figure 2.3 are rules (or higher-order rules), and each of the rules on level 2 has its own prerequisite rules (e.g., "being able to carry a 10"), as well as its prerequisite concepts (e.g., "whole number"). It is fairly common to have 5–10 levels of rules in a hierarchical analysis of a complex skill and 2 or 3 levels of defined concepts. Thus, a typical learning hierarchy might look more like Figure 2.5, which is a minor modification of a hierarchy developed by Robert Gagné (1968, p. 184) himself. It is important to keep in mind that the accuracy of a learning hierarchy can be determined only by testing learners from the target population. If it turns out that learners were able to master one skill without acquiring one connected below it, then the lower one should be removed.

However, a hierarchical analysis could go on seemingly forever. How far down should you continue to break skills into subskills? The purpose of a hierarchical analysis is to identify the prerequisite skills that need to be taught (and the order of the prerequisite relationships among them). Therefore, you do not want to go down beyond the skills that need to be taught. Clearly, skills the learner has already mastered do not need to be taught. So you need to do your analysis only down to the learner's level of "entering knowledge" (at the beginning of instruction). Keep in mind that each individual skill becomes simpler the farther down you go in your analysis, even though each level down is a more complex description of the overall skill being analyzed. This is what I call the hierarchical paradox. Simpler is more complex.

A hierarchical sequence, then, is one that never teaches a skill before its prerequisites (ones immediately below it and connected to it by a line). You could take a spiral approach to hierarchical sequencing by teaching all of the skills on the bottom level of the hierarchy, then moving across the next level up, and so forth. Or you could take a topical approach by moving as far up a "leg" of the hierarchy as quickly as possible for one module of instruction and then moving on to other legs in other modules, always trying to get as high up as you can as soon as you can (these approaches are related to depth-first and breadth-first search techniques in artificial intelligence). Other options are possible, some of which we will look at when we explore the other sequencing strategies in this chapter.

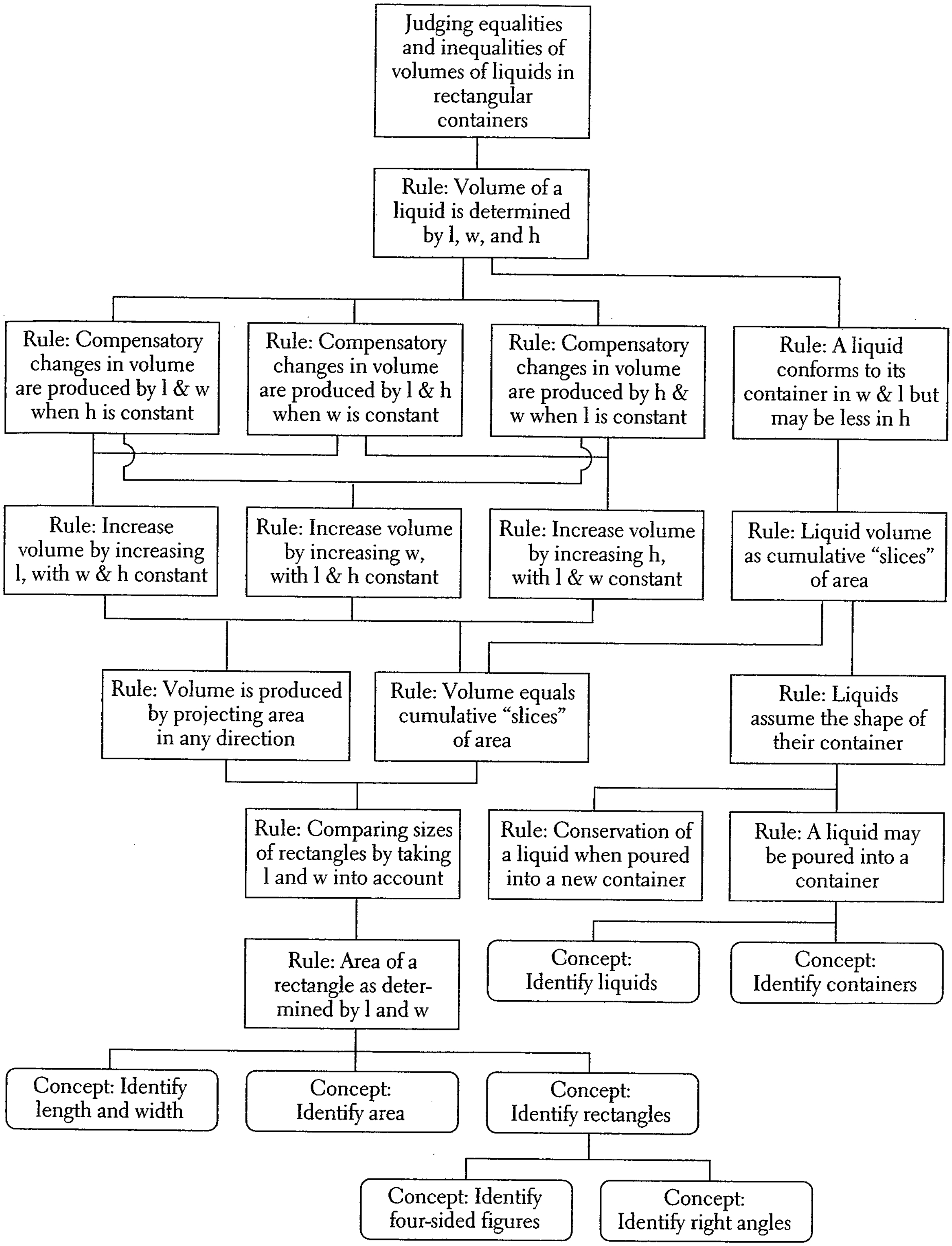


FIGURE 2.5. The results of a hierarchical task analysis (modified from Gagné, 1968). Reprinted with permission of Wadsworth, a division of Thompson Learning.

When and Why to Use Hierarchical Sequences

The strengths of the hierarchical sequence are these:

- In situations where one skill must be learned before another can be learned, it is extremely important to follow the requisite order, for any sequence that violates it is, by definition, doomed to failure (for a learning prerequisite is defined as a skill that must be mastered before it is possible to master a more complex skill of which it is a part).
- The hierarchical sequence is fairly broadly applicable because skills of one kind or another are a major component of most courses in both education and training contexts.
- The sequence is very easy to design once the analysis has been done, and the analysis is not difficult to do nor to learn to do.

The limitations of the hierarchical sequence are these:

- By breaking skills into simpler component parts, the instruction is fragmented, which can be demotivating for the learner and impede valuable schema formation.
- Because it applies to sequencing instruction for a single skill or set of prerequisite (or overlapping) skills, it offers no guidance as to how to sequence skills where one is not a part of the other and is therefore seldom useful for broader sequencing decisions in a large course or curriculum.
- Because it applies only when one skill must be learned before another can be learned, it does not provide any guidance as to how to handle "soft" prerequisites, that is, skills that facilitate learning another skill but are not absolutely necessary for learning it.
- Because it applies only to skills, it is not useful for courses in which skills play a minor role.

The net effect is that hierarchical sequencing is not something that can be violated, but it is seldom sufficient alone for sequencing a course or training program. It can, however, be combined with other sequencing strategies, including all of the remaining ones described in this chapter.

Procedural Sequence

As its name implies, the procedural sequence entails teaching the steps of a procedure in the order in which they are performed. Procedural sequences have probably been used (and fairly well understood) for millennia. They were systematically studied by the behaviorists in the late 1950s and the 1960s under therubric of "forward chaining" sequences (see, e.g., Mechner, 1967). Methodology was further developed by cognitivists in the 1970s under the rubric of "information-processing" sequences (see, e.g., Merrill, 1976, 1980; Resnick & Ford, 1980).

The procedural sequence is also based on a prerequisite relationship, only in this case it is a procedural prerequisite rather than a learning prerequisite. A procedural prerequisite is a step that must be *performed* before another step can be performed in the execution of a given task, whereas a learning prerequisite is a skill that must be *learned* before another skill can be learned.

To design a procedural sequence, therefore, you must first figure out the order in which the steps are performed (i.e., what the prerequisite steps are for each step). This is the purpose of a procedural task analysis, and it usually results in a flowchart of the steps that make up the procedure. Sounds pretty straightforward and easy, doesn't it? Well, not exactly. The problem relates to the hierarchical paradox. To teach someone how to fix cars, our procedural analysis could identify just two steps: (a) Find out what is wrong with the car, and (b) fix it. Clearly, more analysis is needed. We can describe the task at different levels of detail, just like in a hierarchical analysis—that is, we can break steps down into substeps, just as we can break skills down into subskills. But steps and substeps are always Gagné's higher-order rules or rules (specifically procedural or reproductive ones rather than heuristic or productive ones), never concepts or discriminations.

So, what we need to do is a hierarchical analysis in combination with the procedural analysis. We need to break each step down into substeps, and substeps into subsubsteps, and so on until we reach the entry level of the learner. As with the hierarchical analysis, each level of description describes the same procedure in its entirety, as the previous level did, only with more detail. Moreover, the more detailed the description of how to repair an automobile, the simpler each step is to do, even though the whole description seems more complex than our two-step procedure for fixing a car.

(Hence the hierarchical paradox is alive and well in a procedural analysis.) Furthermore, we need to keep in mind that almost every step contains at least one concept, so, once we reach the entry level of the description of the steps, we need to do a hierarchical analysis of those steps to identify any unmastered prerequisite concepts (and occasionally discriminations). Thus the result of a typical procedural analysis might look like Figure 2.6.

A procedural sequence, then, is one that teaches all of the steps in the order of their performance, after they have all been broken down to the learner's entry level. Naturally, it is important to teach prerequisite concepts before teaching the steps in which those concepts are used. Such concepts are often the inputs, the outputs, or the tools for the steps.

When and Why to Use a Procedural Sequence

The strengths of the procedural sequence are as follows:

- In both training and educational contexts, much instruction in the cognitive and motor domains focuses on procedures—learning to follow a set of steps to achieve a goal. For such situations, a procedural sequence is logical to the learner, and the order of learning the steps helps the learner to remember their order of performance.
- Both the analysis and design of the sequence are very quick and easy and do not require much training for the designer.

Because of these factors, the procedural sequence is one of the most common sequences for instruction.

The limitations of the procedural sequence are the following:

- The procedure must not be a very complex one, in the sense of having lots of decision steps and branches, because the methodology offers no guidance as to what to do when you come to a branch—which one to follow first or even whether to teach all of one branch before teaching parts of others.
- The content must be primarily procedural (a set of steps) because the sequence cannot be applied to nonprocedural content.

The net effect is that the procedural sequence is simple and easy to use and quite effective for nonbranching procedures, but it is not sufficient for sequencing a complex branching procedure, nor is it appropriate for dealing with nonprocedural content. It can, however, be combined with other sequencing strategies, including the remaining ones described in this chapter.

Elaboration Theory and Elaboration Sequences

The Elaboration Theory of Instruction was developed to provide holistic alternatives to the parts-to-whole sequencing and superficial coverage of content that have been so typical of both education and training over the past five to ten decades. It has also attempted to synthesize several recent ideas about sequencing instruction into a single coherent framework. It currently deals only with the cognitive and psychomotor domains, and not the affective domain.[4] It is founded on the notions that different sequencing strategies are based on different kinds of relationships within the content and that different relationships are important for different kinds of expertise. So the kind of sequence that will most facilitate learning will vary depending on the kind of expertise you want to develop.

First, the Elaboration Theory makes a distinction between task expertise and subject-domain expertise (see Figure 2.7). Task expertise relates to the learner's becoming an expert in a specific task, such as managing a project, selling a product, or writing an annual plan. Domain expertise relates to the learner's becoming an expert in a subject not tied to any specific task, such as economics, electronics, or physics (but often relevant to many tasks). This is not the same as

4. However, there are strong indications that it can be and indeed is already being intuitively applied in the affective domain. For example, Mark Greenberg and associates (Greenberg, Kusche, Cook, & Quamma, 1995) have developed the PATHS curriculum (Promoting Alternative THinking Strategies), an emotional literacy program designed to help children avoid the road to violence and crime. According to Goleman (1995), "the PATHS curriculum has fifty lessons on different emotions, teaching the most basic, such as happiness and anger, to the youngest children, and later touching on more complicated feelings such as jealousy, pride, and guilt" (p. 278).

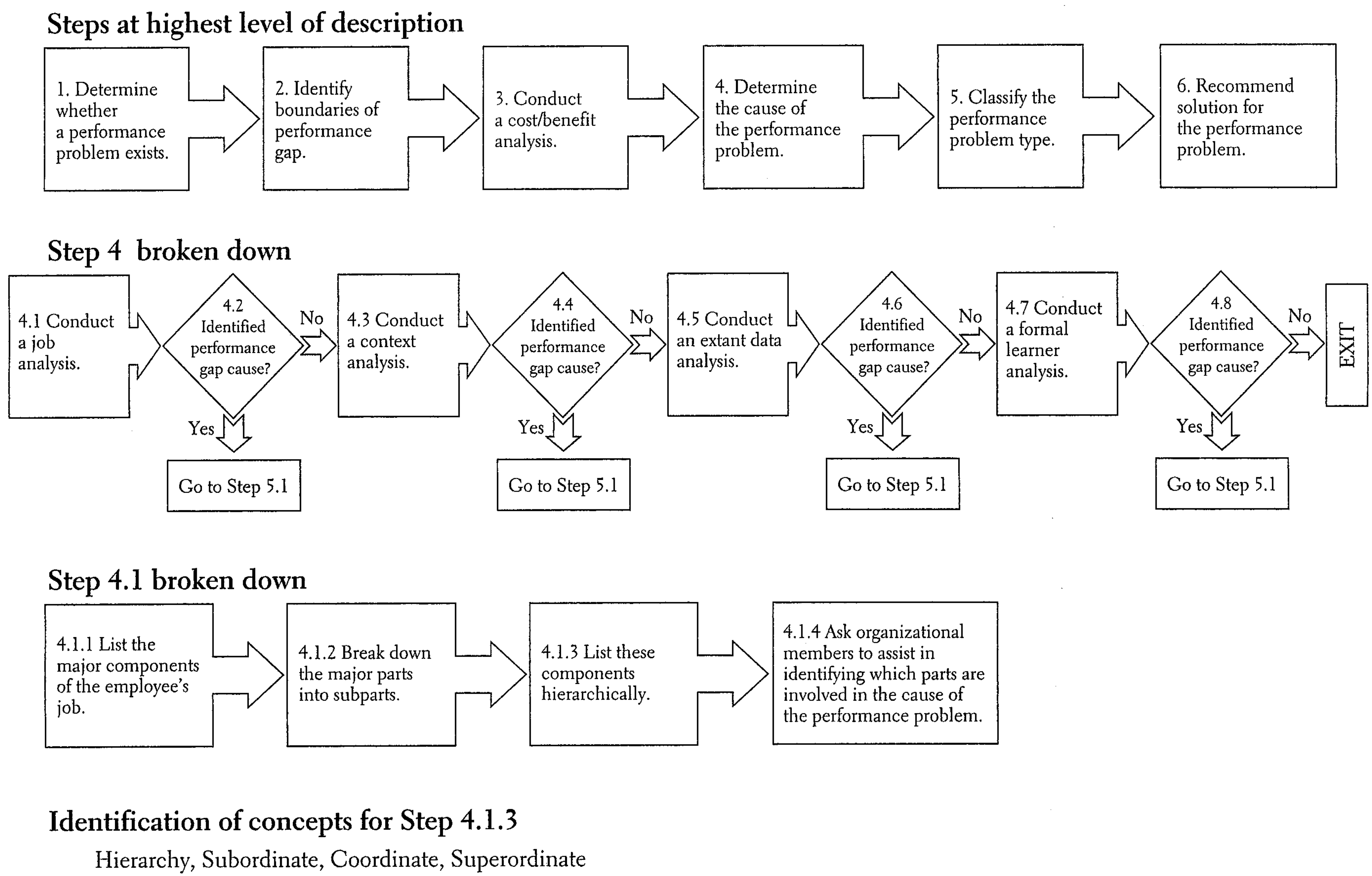


FIGURE 2.6. An example of a flowchart, based on a procedural task analysis for conducting a needs analysis by Terry M. Farmer.

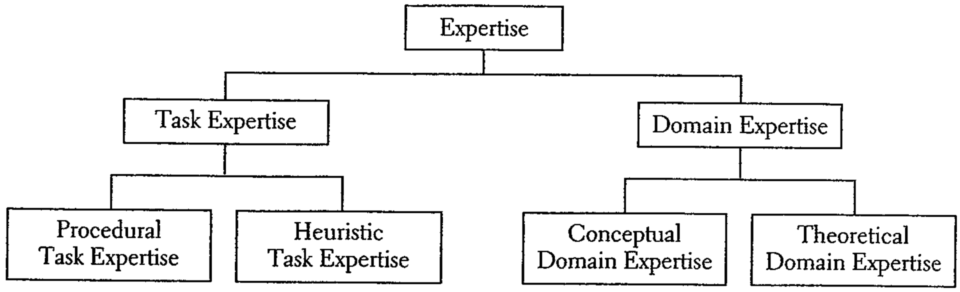


FIGURE 2.7. Kinds of expertise.

the distinction between procedural and declarative knowledge (J. R. Anderson, 1983), for task expertise includes much declarative knowledge, and domain expertise includes much "how to" knowledge.

Task Expertise

Tasks range from simple to complex. The Elaboration Theory is intended only for more complex tasks. It is based on the observation that complex cognitive tasks are done differently under various conditions, that each set of conditions defines a different version of the task, and that some of those versions are much more complex than others. For example, solving mathematical problems is easier when you are solving for one unknown rather than for two unknowns. The number of unknowns is a condition variable having two conditions: 1 unknown and 2 unknowns. Furthermore, skills and understandings of differing complexity are required for each condition. Thus, problems or projects that learners tackle should be ones that are within what Vygotskii (1986) called the "zone of proximal development"—close enough to the learner's competence for the learner to be able to deal with successfully with some help; in addition, the problems should gradually increase in complexity. Thus, the Elaboration Theory offers the Simplifying Conditions Method to design a holistic, simple-to-complex sequence by starting with the simplest real-world version of the task and progressing (by amounts appropriate for the learner) to ever more complex versions as each is mastered.

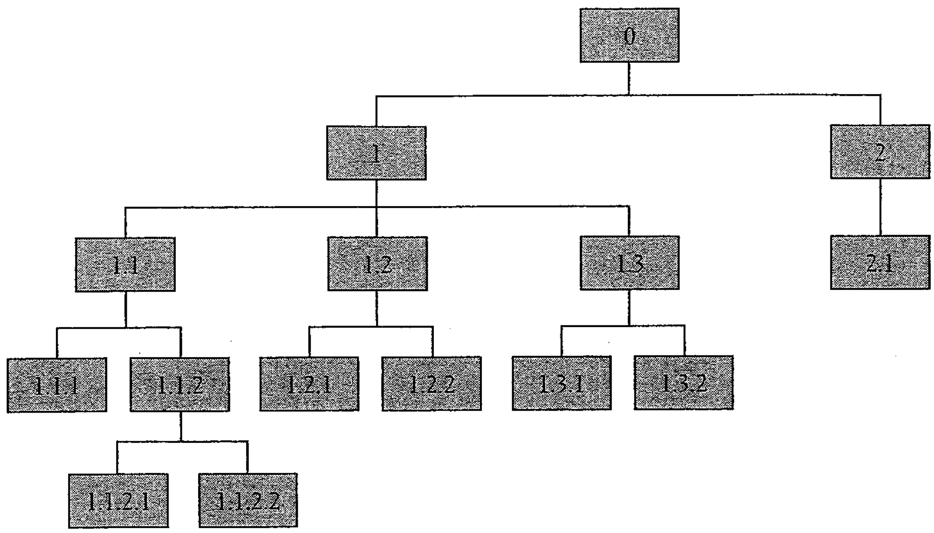
However, not all complex tasks are of the same nature. Some are primarily procedural, and some are chiefly heuristic. Procedural tasks are ones for which experts use a set of mental and/or physical steps to decide what to do when, such as a high school mathematics course or a corporate training program on installing a piece of equipment for a customer. Heuristic tasks are ones for which experts use causal models—interrelated sets of principles and/or guidelines—to decide what to do when, such as a high school course on thinking skills or a corporate training program on management skills). Examples of causal models are found in many of the following chapters, including Chapter 9 by Morik and Mühlenbrock and Chapter 14 by Scheiter and Gerjets.

Domain Expertise

Domain expertise ranges not only from simple to complex but also from general to detailed. And it is the general-to-detailed nature of domain expertise that allows the design of a holistic sequence that goes from simple to complex. The Elaboration Theory's sequencing guidance for domain expertise was derived primarily from Bruner's (1960) "spiral curriculum" and Ausubel's (1968) "advance organizers" and "progressive differentiation," but it differs in several important ways from each and also provides greater guidance as to how to design such a sequence. A domain elaboration sequence starts with the broadest, most inclusive, most general ideas and gradually progresses to more complex, precise ideas. This makes an elaboration sequence ideal for discovery learning and other approaches to the construction of knowledge.

The Elaboration Theory recognizes two major kinds of domain expertise: conceptual (understanding what) and theoretical (understanding why). In their simplest form, these are concepts and principles, respectively, and in their more complex forms, they are conceptual knowledge structures (or concept maps) for "understanding what," as well as both causal models and "theoretical knowledge structures" (see Figure 2.8) for "understanding why." Although these two kinds of domain expertise are closely interrelated and are both involved to varying degrees in gaining expertise within every domain, the guidance for building a holistic, general-to-detailed sequence is different for

When light rays pass from one medium into another (of different optical density):



0	they behave unexpectedly.
1	they bend at the surface.
2	a straight object in both media looks bent at the surface.
1.1	the rays bend because they slow down in a denser medium or speed up in less dense medium (C).
1.2	rays bend and change their distance from each other but remain parallel to each other (A).
1.3	a portion of each ray is reflected off the surface, while the rest is refracted into the new medium (A).
2.1	the apparent position and size of an object usually change (A).
1.1.1	if they pass into a denser medium, the light rays bend toward the normal (B, D).
1.1.2	the greater the difference in optical density between two media, the more the light rays bend (D).
1.2.1	when rays bend toward the normal, they become farther apart (B, D).
1.2.2	the sharper the angle between a light ray and the surface, the more the ray bends (D).
1.3.1	the sharper the angle between a light ray and the surface, the more of each ray that is reflected and the less that is reflected (D).
1.3.2	if the angle is equal or sharper than the critical angle, all of the light ray is reflected (B, E).
1.1.2.1	the index of refraction (n) = c_i/c_r = (sin i)/(sin r) (D, E).
1.1.2.2	the relationship between the critical angle and the index of refraction is sin i_c = 1/n (D, E).

Codes:

(A) What else happens? (B) When? (C) Why? (D) Which way? (D) How much?

FIGURE 2.8. An example of a theoretical structure.

each one. Thus, the Elaboration Theory offers guidance for sequencing for both kinds, and both types of elaboration sequences can be used simultaneously if there is considerable emphasis on both types of domain expertise in a course. This is referred to as *multiple-strand sequencing* (Beissner & Reigeluth, 1994).

What Is an Elaboration Sequence?

The Elaboration Theory has currently identified three types of sequences, one for each of the three types of expertise (see Table 2.2). However, I anticipate that additional ones remain to be identified. Each of these

TABLE 2.2. Types of Elaboration Sequences

Kind of Expertise	Task expertise (procedural and heuristic)	Conceptual domain expertise	Theoretical domain expertise
Kind of Sequence	SCM	Conceptual elaboration	Theoretical elaboration

three is discussed next, along with citations for additional information.

The Simplifying Conditions Method (SCM)

For building task expertise, the Simplifying Conditions Method is a relatively new approach that offers guidance for analyzing, selecting, and sequencing the "what to learn" (content). Briefly, the SCM provides practical guidelines for making a kind of simple-to-complex sequence that is very different from the hierarchical sequence, one that is holistic rather than fragmented. Given that any complex task has some conditions under which it is much easier to perform than under others, an SCM sequence begins with the simplest version of the task that is still fairly representative of the task as a whole. Then it moves to progressively more complex versions of the task until the desired level of complexity is reached, while ensuring that the learner is made explicitly aware of the relationship of each version to the other versions. Each version of the task is a class or group of complete, real-world performances of the task. This sequence contrasts sharply with the hierarchical sequence, which teaches all of the prerequisites first and usually does not teach a complete, real-world task until the end of the sequence. Figure 2.9 shows the differences between the hierarchical approach and the SCM approach.

The SCM (for both procedural and heuristic tasks) is composed of two parts: epitomizing and elaborating. Epitomizing is the process of identifying the simplest version of the task that is still fairly representative of the whole task. Elaborating is the process of identifying progressively more complex versions of the task.

The principles of epitomizing are based upon the notions of holistic learning and schema building. Therefore, epitomizing utilizes:

(a) a whole version of the task rather than a simpler component skill
(b) a simple version of the task
(c) a real-world version of the task (usually)
(d) a fairly representative (typical or common) version of the task

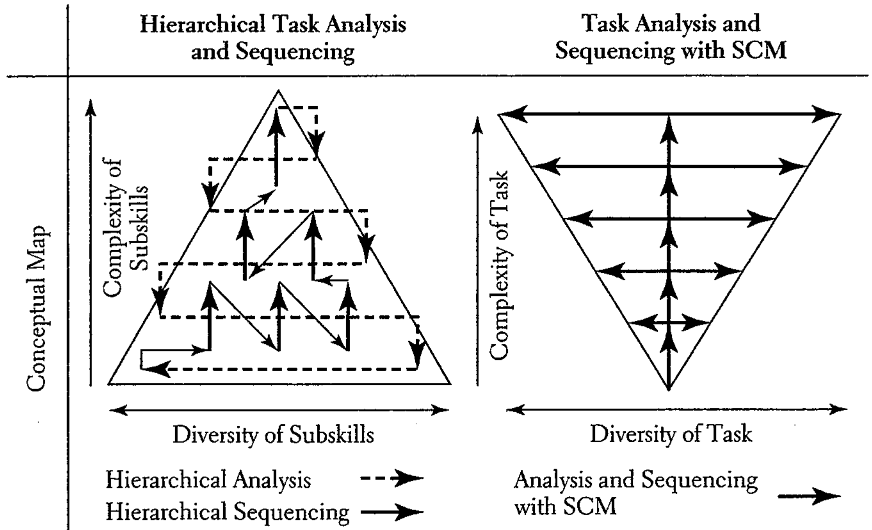
The epitome version of the task is performed by experts only under certain restricted conditions, referred to as the simplifying conditions, that are removed one by one to define each of the more complex versions of the task. Examples are provided in Reigeluth (2006).

The principles of elaborating are similarly based on the notions of holistic learning and assimilation-to-schema. Therefore, each subsequent elaboration should be:

(a) another whole version of the task
(b) a slightly more complex version of the task
(c) an equally (or more) authentic version of the task
(d) an equally or slightly less representative (typical or common) version of the whole task

While the principles of epitomizing and elaborating are the same for both procedural task expertise and heuristic task expertise, they are operationalized a bit differently for each.

The SCM sequence for procedural tasks (Reigeluth & Rodgers, 1980) was derived primarily from the work of Scandura (1973) and Merrill (1976, 1980) on the "path analysis" of a procedure. Every decision step in a complex procedure signals at least two different paths through the flowchart of the procedure (one of which is almost always simpler than the others), and it also represents at least two different conditions of performance. The SCM sequence starts with the simplest real-world version (or path) of the procedural task (a version or path is a set of performances that are done under the same conditions) and gradually progresses to ever more complex versions as each is mastered. The example cited earlier entailed progressing from one unknown to two unknowns in mathematical problems. Some different steps (meaning a different path, requiring different skills and knowledge) are required for each condition.



	Hierarchical Task Analysis and Sequencing	Task Analysis and Sequencing with SCM
Underlying Logic	Part to whole/simple to complex (subskills to main skills)	Simple to complex (simple task to complex task)
For Designer	Task analysis should be done prior to sequencing as a separate task.	Task analysis and sequencing can be done simultaneously. The prototype can be developed rapidly.
For Learner	Facilitates the learning of higher-order skills.	From the very first lesson, it provides 1) the flavor of the whole task; 2) a simple but applicable skill; 3) enhanced motivation.

The hierarchical approach is necessary but not sufficient. It also introduces a very fragmentary approach.

FIGURE 2.9. Hierarchical approach and the SCM approach (from Reigeluth & Kim, 1993).

In contrast, the SCM sequence for heuristic tasks (Reigeluth, 1992; Reigeluth & Kim, 1993) is based on the observation that heuristic tasks are characterized by great variations in the nature of an expert's performance, depending on the conditions of performance—so much so that experts do not think in terms of steps when they perform the task. This sequencing methodology was derived by Reigeluth primarily from the SCM sequence for procedural tasks. Like the procedural SCM sequence, this one also starts with the simplest real-world version of the task and gradually progresses to ever more complex versions as each is mastered. The major difference lies in the nature of the content that is analyzed and sequenced. Rather than a set of steps (with decisions, branches, and paths), you should attempt to identify the underlying tacit knowledge (principles or causal models that are hard to articulate) that experts use to perform the task. Simpler versions require simpler causal models for expert performance. However, because most heuristic knowledge is tacit, for small populations of learners it may be uneconomical to identify all of the heuristics and teach them explicitly to the point of internalization (the solid arrows in Figure 2.10). It may be more appropriate to teach them indirectly by providing problem-based learning or simulations that help the learners to discover the principles through experience (the dotted arrow in Figure 2.10). However, if the learner population is sufficiently large or the efficiency of the instruction is sufficiently important (e.g., you are paying the learners' salaries while they are learning), a heuristic task analysis might be worth the expense. In either case, simplifying conditions should be identified and used to sequence the instruction.

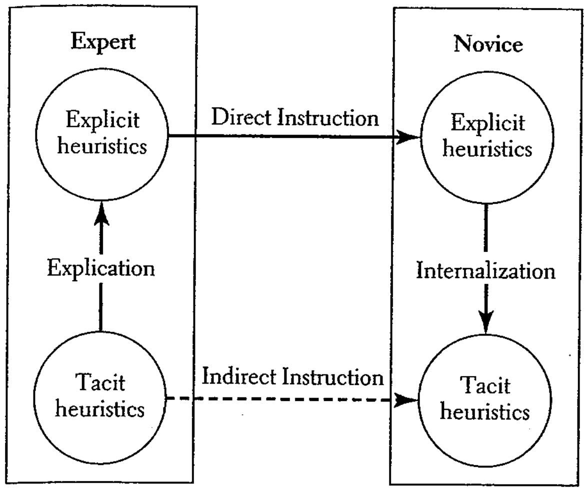


FIGURE 2.10. Two ways to teach heuristics (developed by Yun-Jo An).

Because most tasks entail a combination of both types of knowledge (procedural and heuristic), the SCM sequence is designed to be used simultaneously for both. Additionally, SCM and domain-elaboration sequences can be used concurrently as well. These are referred to as multiple-strand sequences (Beissner & Reigeluth, 1994).

For domain expertise, the conceptual elaboration sequence is described next, followed by the theoretical elaboration sequence.

The Conceptual Elaboration Sequence

For building domain expertise, the conceptual elaboration sequence is one of two sequencing strategies offered by the Elaboration Theory. Both types of elaboration sequences can be used simultaneously (multiple-strand sequencing) if there is considerable emphasis on both types of content in a course (Beissner & Reigeluth, 1994). The conceptual elaboration sequence (Reigeluth & Darwazeh, 1982) is intended for courses that focus on interrelated sets of concepts, which are usually kinds and/or parts of each other. Examples include a high school biology course that focuses on kinds and parts of animals and plants and a corporate training program that focuses on the kinds and parts of equipment the company sells. This sequencing methodology was derived primarily from Ausubel's (1968) "advance organizers" and "progressive differentiation" but provides greater guidance as to how to design that kind of sequence.

The sequence starts with the broadest, most inclusive and general concepts that have not yet been learned and gradually progresses to their ever narrower, less inclusive, and more detailed parts and/or kinds, one level of detail at a time, until the desired level of detail is reached. This can be done in either a topical or spiral fashion (see Figure 2.2). You identify all of these concepts and their inclusivity relationships by conducting a conceptual analysis, which yields a conceptual structure (Reigeluth & Darwazeh, 1982), often referred to as a taxonomy. It is worth noting that the more detailed concepts are not necessarily more complex or more difficult to learn. For example, children usually learn what a dog is long before they learn what a mammal is. One point worth emphasizing is that the conceptual elaboration sequence does not violate the notion of learning prerequisites (hierarchical sequencing).

The Theoretical Elaboration Sequence

The theoretical elaboration sequence (Reigeluth, 1987) is the second of the two sequencing strategies currently offered by the Elaboration Theory for building domain expertise. As indicated earlier, it is intended for courses that focus on interrelated sets of principles at varying degrees of detail. Examples include a high school biology course that focuses on the principles of genetics, life cycles, and bodily functions and a corporate training program on how and why a piece of equipment works. This sequencing methodology was derived primarily from Bruner's (1960) spiral curriculum and Ausubel's advance organizers and progressive differentiation, but it differs in several important ways from each, and the Elaboration Theory also provides greater guidance on how to design the theoretical elaboration sequence than either Bruner or Ausubel provides for their sequences.

This sequence starts with the broadest, most inclusive, most general principles (which are also the simplest and generally the first to have been discovered) that have not yet been learned, such as the law of supply and demand in economics and Ohm's law in electricity. It gradually progresses to narrower, more detailed, precise, complex principles, such as those that relate to maximizing profits on the supply side (e.g., marginal revenues equaling marginal costs) and those that relate to consumer preferences on the demand side of the law of supply and demand. This is done until the desired level of complexity has been reached. Again, this pattern of sequencing can be done in either a topical or spiral fashion. You identify all of these principles and their inclusivity/complexity relationships by conducting a theoretical analysis (Reigeluth, 1987), which yields a theoretical structure (see Figure 2.8). It is worth noting that the more detailed principles are more complex and more difficult to learn.

Other Sequences

The three types of elaboration sequences just described are each based on a single type of relationship within the content. There are likely additional elaboration sequences that fit the basic principles of epitomizing and elaborating described earlier, as well as many sequences that do not (such as the historical sequence, which is based on the chronological relationship among events). But even more important is the utility of thinking about sequencing strategies for different types of courses, in addition to ones for different types of relationships. Often such strategies will be combinations of ones based on relationships, but not always.

The following are some of the types of common courses we have identified that seem likely to benefit from different types of course sequences, but there are surely many more that need to be identified:

- history courses, such as European history or courses on the history of a particular field or discipline, such as physical therapy or economics
- courses on the theory and practice of a particular field, such as physical therapy or electronics
- appreciation courses, such as music appreciation or art appreciation
- philosophy courses, such as the philosophy of education
- science courses, such as biology and physics
- skill courses, such as algebra, English composition, or electronic troubleshooting

It is beyond the scope of this chapter to explore differences in sequencing strategies for these common types of courses, partly because we have been unable to find much work on them.

When and Why to Use Elaboration Sequences

In both training and education contexts much instruction focuses on complex cognitive tasks. The strengths of the SCM sequence for such tasks are as follows:

- SCM enables learners to understand complex tasks holistically by acquiring the skills of an expert for a real-world version of the task from the very first module of the course.
- This understanding in turn enhances the motivation of learners and, therefore, the quality (effectiveness and efficiency) of the instruction.
- The holistic understanding of the task also results in the formation of a stable cognitive schema to which more complex capabilities and understandings can be assimilated. This is especially valuable for learning a complex cognitive task.
- Because the learners start with a real version of the task from the beginning, the SCM is ideally suited to situated learning, problem-based learning, computer-based simulations, and on-the-job training.
- The SCM can be used with highly directive instruction, highly constructivist instruction, or anything in between.

The strengths of the conceptual and theoretical elaboration sequences are these:

- They help to build the cognitive scaffolding (schemata) that makes subsequent, more complex understandings much easier to attain and retain.
- The enhancement of understanding aids motivation.
- These sequences can be used in either directive or constructivist approaches to instruction.

The limitations of the elaboration sequences are the following:

- The content (task or domain expertise) must be fairly complex and large to make the approach worthwhile. With smaller amounts of content, these approaches will not make much difference in the quality of the instruction.
- The elaboration sequences must be used with other sequencing strategies that provide guidance for within-module sequencing. For example, procedural tasks require a combination of procedural and hierarchical approaches for within-module sequencing. As an instructional theory that synthesizes existing knowledge about sequencing, the elaboration theory includes guidelines for using those other approaches with the elaboration approaches.

The net effect is that the elaboration sequences are powerful methods for complex tasks and domains, but they are a bit more complex and hence more difficult to learn, though not much more difficult to use once they are learned. Furthermore, the SCM task analysis procedures and the elaboration sequence content analysis procedures are both very efficient (see Reigeluth, 2006). Because these procedures allow task/content analysis and sequence design to be done simultaneously, it is possible to do *rapid prototyping* so that the first module can be designed and developed before any task or content analysis is done for the remaining modules of the course or curriculum. A rapid prototype can provide a good sample for inspection and approval by clients, higher management, and other stakeholders, as well as for formative evaluation and revision of the prototype, that can strongly improve the design of the remaining modules.

CONCLUSIONS

This review shows several of the major instructional design techniques for ordering instructional content, based on the nature of the content and its interrelationships. It also shows that much remains to be understood about how to sequence instruction for different domains.

The later chapters describe increasingly useful models, but they are ones that need to be developed further to support the needs of instructional design in the field. They are complex enough to support the development of new instructional methods beyond the ones presented here and help validate, illustrate, and teach these design principles.

The following are some general guidelines and principles for sequencing, organized by the order in which decisions need to be made.

Is Sequencing Important?

Decide whether sequencing is likely to make a difference (item 3.2 in Table 2.1). To make this decision, you need to analyze the amount of content and the degree of relationship among the elements of the content (item 3.1 in Table 2.1). If you are teaching a small amount of content (less than about 1 hour of instruction) or you are teaching unrelated topics, then sequencing is not likely to make a difference in school settings, and you can skip the rest of these guidelines and just use your common sense. Be sure to include in the decision-making process the major people who will be implementing the instruction (item 3.4 in Table 2.1). Once you have made the decision, evaluate it by consulting more than one person who is experienced in teaching this content or task (item 3.3 in Table 2.1). They may be the same people you included in the activity for item 3.4 in Table 2.1.

What Kind of Sequence?

If sequencing is likely to make a difference, then you need to decide what kind of sequence to use (e.g., procedural, hierarchical, or elaboration). To do so, you need to analyze the nature of the content (item 3.1). Again, you should include experienced instructors and other end users in the decision-making process (items 3.4 and 3.3, respectively). Considerations for making this decision were described earlier in this chapter.

Design the Scope and Sequence

Once you have decided on the kind of sequence to use, then you need to apply the corresponding scope and sequence methodology to the content (item 3.2). To do this, you need to perform the appropriate type of content or task analysis (e.g., the procedural sequence requires procedural analysis, the hierarchical sequence requires learning prerequisite analysis, and so forth; item 3.1, Table 2.1). The process of conducting the content analysis simultaneously yields decisions about what content to teach (scope), how to cluster it into learning episodes (grouping), and what order to teach those learning episodes (sequence). The following are some general principles that can facilitate making these decisions.

The first factor to consider for sequencing is the size of each learning episode (set of related knowledge and skills). If the learning episode is too big, the learners may forget the early instruction before they have had a chance to review and synthesize what they have just learned. On the other hand, if the learning episode is too small, it will fragment the instruction. The size of each learning episode should also be influenced by the time constraints (if any) of the instructional situation (item 3.1). For example, if you are constrained to 2-hour blocks of time for teaching, then each learning episode should contain 2 hours worth of instructional content (or multiples of 2). Again, you should include end users and other stakeholders in the decision-making process (item 3.4) and have experienced instructors evaluate the resulting sequence (item 3.3).

Second, in addition to considering the size of each learning episode, the components of each learning episode should be considered. The components should be selected based on the relationships among learning episodes that you wish to utilize for your sequence. If you use a procedural sequence, you should include all those steps (and only those steps) that are performed in the same period of time. If you use a hierarchical sequence, you should include only those skills that are prerequisites for the same skill (or set of skills).

Third, the order of the learning episodes should be considered. Presenting too much complexity too soon or presenting the learning episodes in an illogical order will discourage the learner, slow down the learning process, and reduce the chances of mastering the topic or task. The order of these episodes will also depend on the relationship chosen. If you choose a procedural sequence, each set of steps (which constitutes a learning episode) should be taught in the order in which an expert performs it.

Design the Within-Episode Sequences

Once you have finalized the content for your learning episodes and sequenced them, you need to order the content within each learning episode (item 3.2). The sequencing of elements such as prerequisites and relevant information, understandings, and attitudes can influence the quality of the instruction. For example, if you teach nothing but the prerequisite skills (which are less interesting) in the first half of the learning session, learners may become bored and give up before they taste the real flavor of the topic or task, and they may forget the earlier ones before they have an opportunity to use them.

Various principles of sequencing are likely to be relevant here, such as "Teach prerequisites immediately before they are needed" (the just-in-time principle) and "Teach understanding before efficient procedures." Each of these principles requires a different type of analysis of the content (item 3.1). And, of course, you should include end users and other stakeholders in the decision-making process (item 3.4) and have experienced instructors evaluate the resulting within-learning-episode sequences (item 3.3). Reigeluth (2006) addresses further considerations for making these decisions.

The components and the order of each learning episode are strongly interrelated. The order will be influenced by the components. Therefore, the order should be selected by first determining which relationships should be emphasized and thus the components each learning episode should have. Some guidance for making this decision was presented earlier in this chapter.

What's Next?

Further research on sequencing instruction will need to advance our knowledge of sequencing strategies for different types of courses, such as those mentioned earlier (history, theory and practice, appreciation, philosophy, etc.). Additional research is also needed on how best to identify heuristic knowledge, which is often tacit knowledge unbeknownst to the expert (see, e.g., Dehoney, 1995; Lee & Reigeluth, 2003; Schraagen, Chipman, & Shalin, 2000). This requires advances in the heuristic task analysis process. Finally, research is needed on applying the principles of the Elaboration Theory to the affective domain.

PROJECTS AND OPEN PROBLEMS

1. Would any of the elaboration sequences (conceptual, theoretical, or simplifying conditions) be appropriate for a course that you teach (or have taught or might teach)? If so, which one? Prepare an outline of the learning episodes and their sequence.
2. What additional course-sequencing strategies can you think of, besides those listed earlier (historical, theory and practice, appreciation, philosophy, etc.), that are not offered by the hierarchical, procedural, and elaboration sequences? What major guidelines would you offer for such a course? Feel free to email your ideas to me at reigelut@indiana.edu.
3. How would you apply Elaboration Theory principles to teaching attitudes and values, such as the values of hard work, service to others, and integrity?
4. How can the theory and tools from later chapters help teachers in schools to improve their instruction? Interview a teacher to learn what that

person needs from a theory to teach more effectively.

5. Consider how to teach teachers about sequencing strategies. What would be a good order? Create a figure like Figure 2.3 or 2.5 for teaching sequencing strategies.

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