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pp. 22-32
C. 1

The Elaboration Theory's Procedure For Designing Instruction

A Conceptual Approach

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Abstract. This paper describes the use of elaboration theory in selecting, sequencing, synthesizing, and summarizing instructional content that is predominantly conceptual in nature. A brief summary of the elaboration theory is provided, as well as a description of the major works that the elaboration theory has incorporated or built upon. A nine-step procedure is presented which can be used by designers and teachers working together as a team. The procedure involves (1) deciding when to use a conceptual approach, (2) selecting the concepts to be taught and organizing them into knowledge structures, (3) deciding what is the most inclusive of those knowledge structures, (4) arranging that knowledge structure's concepts in a general-to-detailed sequence that will provide the "skeleton" or basic structure of the course, (5) identifying other ideas and facts that should also be taught (including learning prerequisites) and adding "flesh" to the skeleton of the course by allocating each such idea and fact to its most highly related "skeletal" concept, (6) allocating all content to lessons, (7) sequencing the content within each lesson, (8) designing the test items and instruction on each individual piece of content (i.e., on each concept, principle, procedure, and fact), and (9) creating synthesis test items and instructional components. Prescriptions for developing instruction on a single piece of content (step 8 above) are based on Merrill's component display theory.

Instructional design and development are much like architecture and construction, respectively. Like a building, instruction should be planned and then created. To the extent that the plan is based on ideas of proven utility, it is likely that an effective product will be produced. The result of instructional design is a "blueprint" of the instruction that is about to be created. An architect might have a standard blueprint for a hospital, another for an elementary school, another for a three-bedroom house, and so on. In a similar way, an instructional designer can benefit from having a set of *models* of instruction, each of which would be used as a "standard blueprint" for meeting a different kind of content, or different kind of learner). Such a set of models of instruction, together with the bases for prescribing when to use each, comprise a *prescriptive theory of instruction*, such as the elaboration theory. Of course, one must not forget that, like an architect, an instructional designer almost always modifies the "standard blueprint" in certain ways to accomodate the specific needs of the project at hand.

Once an architect has created the specific blueprint for a project, a constructor works to create the building under the watchful eye of the architect. In a similar way, subject matter experts and experienced teachers *develop* the instruction under the supervision of the designer. Both the designer and the developers follow certain *steps* in order to perform their duties.

The purpose of this paper is to describe a set of steps that both designers and developers might follow in order to effectively utilize the "standard blueprints" represented by the elaboration theory. However, it is beyond the scope of this short paper to describe such a set of steps for all three of the "standard blueprints" of the elaboration theory. Hence, this paper will deal with only one of those standard blueprints: that which is referred to as the *conceptual organization*. Before we start our description of the steps for

designing and developing instruction, it may be useful to many readers to have a brief background about the elaboration theory. All elaboration theory technical terms used below are defined in the glossary in Table 1.

What Is the Elaboration Theory?

As was mentioned above, the elaboration theory is a set of "standard blueprints" as to what instruction should be like in order to meet different needs. At its present stage of development, it is intended exclusively for the *cognitive domain* (Bloom, 1956) and we believe that it is particularly inappropriate for the affective domain. Within the cognitive domain, the intention is to make it fully applicable for all kinds of goals, content, learners, and situations. For example, it can presently prescribe: models for teaching such "generic" cognitive strategies as discovery skills and thinking skills, models for teaching pure memorization level objectives, and models for virtually every kind of cognitive objective in between. Hence, it covers all of the levels of Bloom's taxonomy, plus an additional level which is often referred to as "meta-cognition."

As a set of prescriptive models of instruction, the elaboration theory has attempted to *integrate all* of the useful current knowledge about learning and instruction, regardless of the "theoretical perspective" out of which it was developed (e.g., behavioristic, cognitive, humanistic). In many cases, the major differences between these different perspectives are the *goals* that their instructional methods are intended to achieve: behavioristic being content-specific skills, cognitive being generic skills such as discovery, and humanistic being self-actualization. When those differences are discounted, the methods espoused by the different theoretical perspectives are remarkably similar (see e.g., Reigeluth, in press).

When one identifies that the content of cognitive instruction is comprised of facts, concepts, principles, and procedures, it becomes convenient to think of two major classes of methods of instruction: (1) those which apply to teaching a *single* idea (i.e., a single fact, concept, etc.) which we have referred to as micro strategies, and (2) those which apply to a whole *set* of related ideas, which we have referred to as macro strategies. Micro strategies include such things as the use of examples, practice, feedback, and diagrams, because they all help a student to learn a single idea. Macro strategies include such things as the *selection* of ideas which will be most instrumental in achieving the goals of the course, the *sequencing* of those ideas so as to maximize the ease, speed, and permanence of the learning, the *synthesis* of (or the showing of interrelationships among) related ideas, and the systematic *summarizing* (preview and review) of the ideas that have been taught.

Initially, the elaboration theory was restricted to the *macro* level, but it has since subsumed a similarly eclectic instructional theory on the micro level: Merrill's component display theory (Merrill, in press; Merrill, Reigeluth, & Faust, 1979; Merrill, Richards, Schmidt, & Wood, 1977; Merrill & Wood, 1975). In addition, Keller's strategies for the motivational design of instruction (Keller, 1979; in press) are currently being integrated into the elaboration theory.

With respect to macro strategies, the elaboration theory incorporates aspects of the work of Ausubel (1968), Bruner (1960, 1966), Gagne (1968, 1977), Norman (1973), P. Merrill (1978, 1980), Resnick (1973), Scandura (1973, in press), and others. It draws on Ausubel's specification for the use of general-to-detailed (or, more precisely, subsumptive or assimilitive) sequencing as a primary organizational strategy, and the use of periodic "integrative reconciliation" of content within the learner's cognitive structure. It draws on Bruner's notion of a "spiral curriculum," which is an approach to sequencing instruction that entails teaching ideas initially in a general, simplified, yet "intellectually honest" form, and periodically cycling back to teach those same ideas in progressively more complete and complex form. It draws on Gagne's notion of learning hierarchies, or learning prerequisites, which involves the fact that some knowledge must be acquired before other knowledge can be acquired. The elaboration theory also draws on Norman's notion of "web learning," which entails the use of an initial, broad, conceptual outline or schema of to-be-acquired content, followed by progressively more detailed and specific information. And it draws on work that P. Merrill, Resnick, Scandura, and others have done on an information-processing approach to task analysis and on the use of "path analysis" (P. Merrill, 1978) as a method for sequencing instruction.

As is indicated by the above, the purpose of elaboration theory is to create a comprehensive set of models that integrate most of our existing knowledge about instruction in a way that will greatly improve our ability to design good instruction. Although much useful knowledge remains to be integrated into it and much validation (and possible revision) is needed, the elaboration theory is presently capable of providing considerable guidance in the creation of instructional "blueprints."

At its current stage of development, the elaboration theory of instruction prescribes that the instruction follow a special kind of *general-to-detailed sequence* that is intended to build stable cognitive structures and to always provide a meaningful context for any given piece of the instructional content. This general-to-detailed sequence starts by presenting a special kind of overview lesson that *epitomizes* a *single type of content* (called the "organizing content") and includes whatever of the other types of content are highly relevant. (Epitomizing differs from summarizing in that it presents but a few ideas at the application level rather than many ideas at the memorization level.) The remainder of the lessons present progressively more detailed organizing-content ideas which elaborate on earlier ones. Naturally, whatever of the other types of content are highly relevant are also included in each lesson along with the organizing-content ideas. The lessons are organized into layers of detail or complexity, with

> "The elaboration theory has attempted to *integrate all* of the useful current knowledge about learning and instruction, regardless of the 'theoretical perspective.' "

about three to ten lessons elaborating directly on any single lesson. The degree of *learner control* over selection and sequencing is not dictated by the theory; but our own preferences are generally for as much learner control as possible.

The organizing content may be concepts, principles, or procedures; and it is selected on the basis of the overall goals of the course (or curriculum). A *concept* is a set of objects, events, or ideas that share certain characteristics (e.g., "fish" is a concept). A *principle* (or proposition or hypothesis) is a change relationship, usually a cause-and-effect relationship (e.g., the relationship between cold blooded animals' body temperature and the external temperature is a principle). And a *procedure* (or technique, method, or skill) is an ordered set of actions for achieving a predetermined goal (e.g., the steps that somebody follows to design instruction is a procedure). Depending on whether the goals of the course emphasize learning "what," "why," or "how to," the elaboration theory prescribes a conceptual, theoretical, or procedural organization. But such a selection only provides the basis for planning the elaborative sequence; it does not preclude the other types of content from being included in all lessons.

In addition to structuring lessons in an elaborative sequence of organizing content, the elaboration theory also prescribes an internal structure for each lesson. Each lesson should start with a *motivational* strategy component, such as the creation of an incongruity (see Keller, in press); but such strategy components have not yet been adequately integrated into, and specified by, the elaboration theory. Then the lesson presents an *analogy* if a good one can be found and is believed to be necessary and useful. Next, it presents the *organizing content ideas* in a "most fundamental, most representative, most general, and/or most simple first" sequence. However, each of these ideas is directly preceded by all of its *learning prerequisites* that have not yet been mastered by all of the target learner population. Each of the organizing content ideas may also be directly followed by any *supporting content ideas* (those kinds of ideas that are not the organizing content) that have been selected as highly relevant to it. Alternatively, it may be best to group all of those supporting ideas for presentation

after all of the organizing content ideas have been presented, especially if those supporting ideas are highly interrelated.

All of the ideas in the lesson are presented according to *component display theory* specifications (Merrill, in press; Merrill, Reigeluth & Faust, 1979; Merrill, Richards, Schmidt, & Wood, 1977). Finally, a summarizer and a synthesizer are presented. The *summarizer* is a specific kind of summary which provides a concise generality, a reference example, and a "self-test" practice items for each idea that was taught in the lesson. The *synthesizer* teaches interrelationships among the ideas that were just taught by presenting a subject-matter structure (Reigeluth, Merrill, & Bunderson, 1978; Reigeluth & Stein, in press), integrated examples, and integrated practice items. Also, *cognitive strategy activators* (Rigney, 1978) are included wherever they are needed and appropriate, as are additional motivational strategy components.

The above description is a brief summary of the elaboration theory in its current stage of development. For a more detailed description, see Reigeluth and Stein (in press). The remainder of this article describes the procedure for designing and developing instruction according to the elaboration theory. However, as was mentioned above, due to space limitations we will only present the procedure for *conceptual organizations*. The procedure for procedural organizations is described in Reigeluth and Rodgers (1980). The procedure for theoretical organizations remains to be published. Finally, for a specific application of the procedure to textbook development and evaluation, see Reigeluth & Sari (1980) and Sari & Reigeluth (in press.)

The Design-development Procedure for a Conceptual Organization

The following procedure is based on

standard instructional development procedures, such as the IDI (Instructional Development Institute) procedure (Twelker, Urbach, & Buck, 1972). It requires (1) an instructional designer (the "architect") who is experienced in the use of the elaboration theory and (2) several teachers (the "builders") who are experienced in teaching the content of interest to the student population of interest. The differentiation of roles in this "team approach" is crucial to the success of the development effort.

This procedure for designing and developing instruction according to the conceptual organization of the elaboration theory has nine major steps:
Step 1. Decide to use a conceptual organization.
Step 2. Select all the concepts to be taught and arrange them into kinds and parts conceptual structures.
Step 3. Decide which of all the conceptual structures should be used as the organizing structure for the course.

"An instructional designer can benefit from having a set of *models* of instruction, each of which would be used as a 'standard blueprint' for meeting a different need."

Step 4. Allocate all concepts in the organizing structure to the levels of detail.
Step 5. Identify the supporting content for each organizing content idea.
Step 6. Allocate all content within each level to lessons and sequence them.
Step 7. Sequence all content within each lesson.
Step 8. Design the test items and instruction on each individual concept, principle, procedure, and fact within each lesson.
Step 9. Create the synthesis test items and the remaining components of the instruction for each lesson.
Each of these nine steps is described in some detail below.

Step 1: Decide on a Conceptual Organization

The instructional designer and experienced teachers help the client to decide, on the basis of the goals of the course, whether or not *concepts* represent the most important kind of content

to be learned in this course. Concepts are usually the most important kind of content if the course is primarily concerned with "what," whereas principles and procedures are usually the most important if the course is primarily concerned with "why" or "how," respectively. Usually, a "general education" course will emphasize concepts as the most important kind of content. But remember that whichever one is selected as the organizing content, the other two types of content are not omitted — they are included whenever and wherever appropriate (see Step 5 below).

We will use a biology course on animals to illustrate the design procedure. In this case, the teachers have indicated that they feel that the most important thing for the students to learn is *what* the most important kinds of animals are and *what* characteristics each has. Hence, the client has agreed on a conceptual organization.

Step 2: Select all Concepts to Be Taught

Step 2 entails selecting all the concepts that are to be taught and arranging them into kinds and parts conceptual structures. To do this, you should follow these substeps:

2.1 Make sure the experienced teachers understand the notions of superordinate, coordinate, and subordinate relations among concepts and the notion of parts-ordinate and kinds-ordinate varieties of those relations. Detailed descriptions of those kinds of relations can be found in Reigeluth, Merrill, and Bunderson (1978) and Reigeluth and Stein (in press).

2.2 Have the teachers identify the most general and inclusive concepts in the subject-matter area to be taught.

2.3 For each of the concepts, have the teachers start to derive both a parts conceptual structure and at least one kinds conceptual structure. This is done by dividing each concept into its most general *parts* on one piece of paper and into its most general *kinds* on another. (Note: you may find that there is more than one dimension — or way — in which a concept can be divided into kinds. For example, fish could be divided into tropical fish, etc., or into fresh water fish, etc., or .... Encourage the teachers to look for all important dimensions.)

2.4 Continue to derive a parts conceptual structure and at least one kinds conceptual structure by successively dividing each part and each kind into its most general parts and kinds, respectively.

2.5 Have the teachers check to make sure that all concepts are appropriate to teach in this course and that no important concepts for the course have been omitted.

Returning to our biology example, Figures 1 and 2 illustrate the nature of the results of this step. In Figure 1, animals were broken down into *kinds*: cold-blooded animals and warm-blooded animals. Cold-blooded animals were further broken down into reptiles, fish, etc.; reptiles were further broken down into turtles, snakes, etc.; and so on. In Figure 2, the human body was broken down into *parts*: circulatory system, digestive system, etc.; circulatory system

was further broken down into heart, arteries, etc.; and so on. Due to space limitations, we have included only a sample of kinds and parts in those figures, and those two figures represent only a small sample of all the kinds and parts conceptual structures that would be developed during this step. Although biology is especially easy to analyze for conceptual structures, our experience has not yet revealed any subject-matter areas in which sufficiently inclusive and extensive conceptual structures cannot be built.

Step 3: Select the Organizing Structure.

The following substeps can be used to decide which of all the conceptual structures from Step 2 should be used as the organizing structure — the structure that determines the general-to-detailed sequence for the course.

3.1 The designer helps the teachers to decide which conceptual structure contains the most inclusive and important of all the concepts that were selected in Step 2 (i.e., which conceptual structure subsumes the greatest number of all the concepts for the course, and includes the most important concepts in relation to the goals of the course). For example, the kinds conceptual structure shown in Figure 1 would probably be selected as the most inclusive and important one — that is, practically all of the other concepts that are to be taught provide more knowledge about these concepts, and these concepts are among the most important in the whole course.

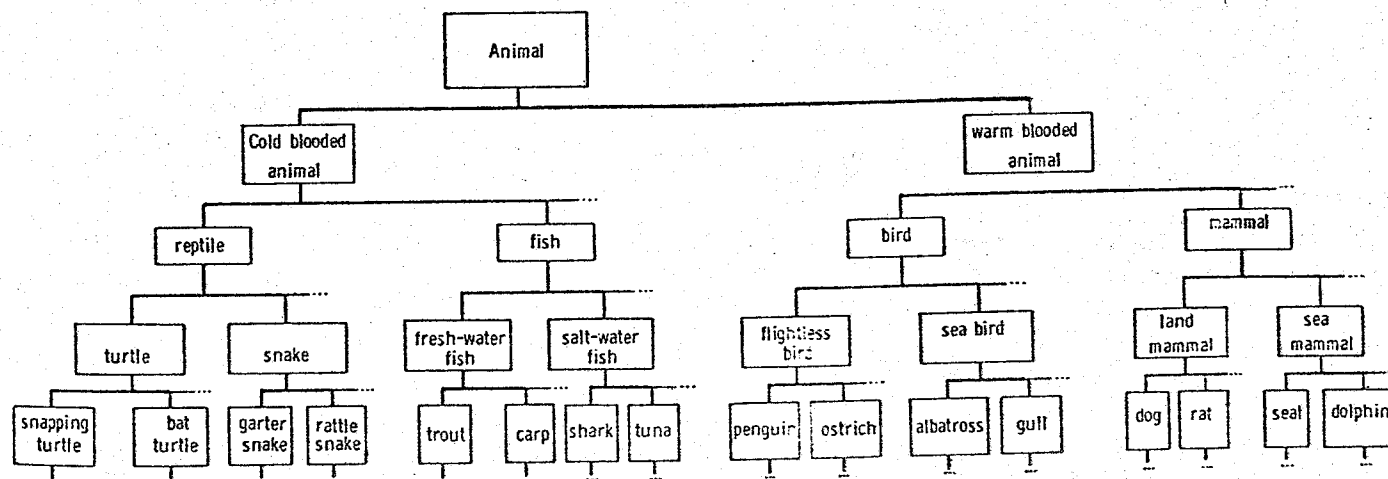3.2 The designer helps the teachers to identify any other conceptual structure

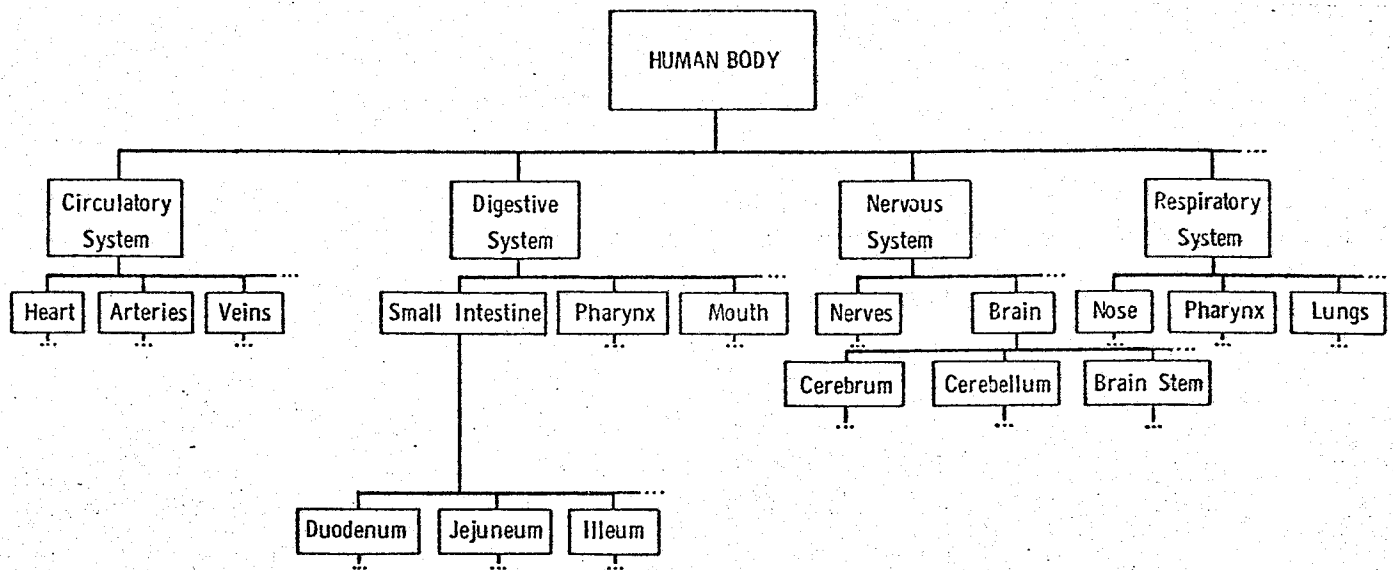Figure 1. A portion of a kinds conceptual structure.

Figure 2. A portion of a parts conceptual structure.

which could be usefully combined with the first to form a matrix. The matrix is a structure which has kinds on one dimension and either kinds or parts on the other. The intersection of the two dimensions identifies a third set of concepts (see Figure 3). In addition, each dimension is part of a conceptual structure (either kinds or parts), and the next level down on each of those two structures can also be combined into a matrix structure, which identifies a more detailed version of the "third set of concepts" mentioned above. (See Reigeluth, Merrill, & Bunderson, 1978, and Reigeluth et al., 1980, for more about matrix structures). If a good matrix structure is found, then it (complete with its different levels) serves as the organizing structure. Otherwise, the conceptual structure identified in 3.1 serves as the basis for organizing the elaborative (general-to-detailed) sequence for the course.

Step 4. Allocate Concepts in the Organizing Structure to Levels of Detail

This step entails allocating all concepts in the organizing structure to different levels of detail (including the epitome and all levels of elaboration). The following are the substeps for doing this:

4.1 To decide which concepts to teach in the epitome, prune the conceptual organizing structure from the bottom up until you reach a small enough number of concepts for the student to be able to learn and synthesize in one lesson (about one hour). In the case of a matrix structure, both dimensions

would have their conceptual structures pruned in a similar manner, and the remaining concepts would be combined into the epitome version of the matrix.

4.2 The concepts for the first level of elaboration are the ones comprising the highest level of the organizing structure (or structures, in the case of a matrix) that is missing from the epitome.

4.3 This process is repeated until all concepts in the organizing structure(s) have been allocated to different levels of elaboration.

Using the kinds conceptual structure shown in Figure 1 as the organizing structure, the *epitome* would include the concepts of animal, cold-blooded animal, and warm-blooded animal. The *first level* of elaboration would include the next level of concepts: reptile, fish, birds, and mammals (see Figure 1 above). The second level of elaboration would consist of the next level of subordinate concepts, which includes: turtle, fresh-water fish, flightless birds, and land mammals. And the third level would consist of the next level of concepts, which includes: snapping turtle, carp, penguin, and dog (see Figure 1 above), the result of this step is similar to the blueprint shown in Figure 4.

Step 5. Identify Supporting Content for Each Organizing Content Idea

In this step the designer should help the teachers to identify all the supporting content ideas that are highly related to each concept in the organizing structure. If it is not highly related (i.e., the teachers do not really expect the students to learn it), then it should not be

included as course content. To do this step, you should follow these substeps:

5.1 For each *concept* that was identified in Step 2 as important but is not included in the organizing structure, decide what organizing concept(s) it is most closely related to, and allocate it to that concept's level of elaboration. In general, supporting content should not be included before it is highly related to some organizing content which is being presented. It may be best to teach many of these supporting concepts after *all* organizing concepts have been taught.

5.2 Identify all important *principles* that are highly related to each concept. Be sure to only include those principles that are important, given the goals of the course. Allocate each such principle to the level of elaboration in which its first highly related concept appears. If it is not *highly* related to any organizing concepts, it should be presented after *all* organizing concepts have been taught.

5.3 Identify all important *procedures* that are highly related to each concept. Allocate each to the level of elaboration in which its first highly related concept appears. Again, it may be presented after *all* organizing concepts have been taught.

5.4 Identify all important *facts* that are highly related to each concept. Allocate each to the level of elaboration in which its highly related concept appears, or after *all* organizing concepts.

5.5 For each of the ideas identified above (including principles and procedures), identify all *learning prerequisites* down to the level of entering behavior for the target student popula-

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

Figure 3. A portion of a matrix structure (or table) combining two kinds conceptual structures.

KEY: In this matrix structure, each box is a kind of both its row heading and its column heading.

LESSONS		ORGANIZING CONTENT (Concepts)
1.	Epitome	animal cold-blooded animal warm-blooded animal
2.	First level of elaboration	reptile fish bird mammal
3.	Second level of elaboration	turtle snake fresh-water fish flightless bird sea bird land mammal sea mammal
4.	Third level of elaboration	snapping turtle bat turtle garter snake rattlesnake trout carp shark tuna turkey ostrich albatross gull dog rat seal dolphin

Figure 4. A partial "blueprint" illustrating the nature of the results of steps 1-4.

tion. The experienced teachers should have the necessary knowledge about the target student population to perform this step, but the designer should emphasize the importance of basing the decision on the *lowest-ability* entering student. Beware that teachers tend to overestimate the entering knowledge of their students.

Returning to our biology example, the following are illustrative of the supporting content that would be identified:

1. *Conceptual supporting content.* This would include such concepts as "kinds of habitats" (e.g., jungle, savannah, coral reef, etc.). Each of the kinds of habitats would be introduced at the level which introduces a type of animal that is restricted to a single kind of habitat. (Note: If kinds of habitats were believed to be important enough, it could have been selected as the organizing structure or as part of a matrix organizing structure.)

2. *Theoretical supporting content.* This would include such principles as "balance of nature" and "natural selection." Natural selection would be introduced with a particular kind of animal for which the principle serves to explain the presence of some extraordinary features, such as a chameleon's ability to change color. Naturally, the same principle is likely to be reintroduced at some later time when another animal with such extraordinary features is introduced.

3. *Procedural supporting content.* This would include such things as the way a certain type of animal hunts for food and the steps an animal follows during courtship. Each of these procedures would be introduced along with (or just after) the concept (type of animal) that it relates to.

4. *Factual supporting content.* This would include such things as the number of a certain type of animal that is in existence today, whether that type of animal is on the endangered species list, what continents or countries it lives in, and something about the history of that type of animal. Naturally, this kind of content would be included when or just after the concept (type of animal) itself is introduced.

5. *Learning prerequisites.* The concepts of animal, temperature, environment, and self-regulation are prerequisites for either the concept "cold-blooded animal" or "warm-blooded animal."

An example of the results of this step

is shown in Figure 5.

Step 6: Allocate Content within Each Level to Lessons and Sequence Them

This step entails allocating all the content on each level of elaboration to different lessons and deciding on the sequence for those lessons. Sequencing could be fixed or variable. If it is *fixed*, then all students will be forced to follow a single, linear pattern of progression from one lesson to another. In this case, the designer and teachers must decide what sequence of lessons will be best. If it is *variable*, then the students will be following different patterns of progression through the lessons. Hence, the designer and teachers need to decide what sequencing options will be permissible among the lessons.

6.1 Allocate each organizing concept on a level to a lesson and put all supporting content in the same lesson as its corresponding organizing content. Each lesson should be neither too large nor too small (neither too many nor too few ideas and facts). If it is too large, achievement and motivation will suffer, and there will be too much content to be effectively synthesized at the end of the lesson. If it is too small, the high frequency of the review and synthesis will reduce the efficiency of the instruction and demotivate the learner. The proper amount of content for a lesson is referred to as the "optimal learning load," which varies with the difficulty level of the content in relation to the ability level of the learners. We roughly estimate that it should represent about an hour of instruction, but research is needed to test this estimate. The amount of content in a lesson can be adjusted to the optimal learning load by adding another organizing concept (along with its supporting content) if the load is too light (see Step 6.2), or by splitting some supporting content out into a separate lesson if the load is too heavy.

6.2 Whenever two or more organizing concepts need to be grouped into a single lesson to create an optimal learning load, you must decide which concepts should be grouped together. They should be grouped on the basis of relatedness. If the concepts being considered for grouping are about equally related, then size may be the most important factor for making grouping decisions.

In reference to the biology example, Lesson 1 will include all the organizing and supporting content listed for the epitome (see Figure 5). *Lesson 2* will

LESSONS	ORGANIZING CONTENT (CONCEPTS)	CONCEPTUAL SUPPORTING CONTENT	THEORETICAL SUPPORTING CONTENT	PROCEDURAL SUPPORTING CONTENT	FACTUAL SUPPORTING CONTENT	LEARNING PREREQUISITE
Epitome Lesson	Animal cold-blooded animal warm-blooded animal	Parts of warm-blooded animals Parts of cold-blooded animals	The process whereby warm-blooded animals' body temperature is maintained constant.	Ways that cold-blooded animals influence their body temperature	Some warm-blooded animals have higher body temperature than others. ...	Temperature environment self-regulating ...
Level-1 Lessons	Reptiles Fish	...	...	How reptiles warm up ...	Comparison of numbers of reptiles, fish, birds, and mammals.	...
Level-2 Lessons	Turtles Snakes Fresh-water fish Salt-water fish Flightless birds Sea birds Land mammals Sea mammals...	Kinds of habitats ...	Natural selection ...	How turtles protect themselves ...	...	...
...	...	...	...	...	...	...

Figure 5. A partial "blueprint" illustrating the nature of the results of steps 1-5.

Lessons	Organizing Content (concepts)	Conceptual Supporting Content	Theoretical Supporting Content	Procedural Supporting Content	Factual Supporting Content	Learning Prerequisites	Lesson(s) which may follow
Epitome Lesson 1	Animal Cold-blooded animal Warm-blooded animal	Parts of warm-blooded animals Parts of cold-blooded animals ...	The process whereby warm-blooded animals' body temperature is maintained constant.	Ways that cold-blooded animals influence their body temperature ...	Some warm-blooded animals have higher body temperature than others. ...	Temperature environment self-regulating ...	2 or 3
Level 1: Lesson 2	Reptiles Fish	...	ı ...	How reptiles warm up ...	Comparison of numbers of reptiles and fish ...	...	3, 4, or 5
Lesson 3	Birds Mammals	...	...	...	Comparison of numbers of birds and mammals ...	...	
Level 2: Lesson 4	Turtles Snakes	Kinds of habitats -desert -swamp ...	Natural selection Protective mechanisms ...	How turtles protect themselves ...	...	...	3, 5, 8, 9, 10
Lesson 5	Freshwater fish Saltwater fish	...	...	...	...	...	3, 4, 11, 12
Lesson 6	Flightless birds Sea birds	...	...	...	...		

Figure 6. A partial "blueprint" illustrating the nature of the results of steps 1-6.

include two related organizing concepts from level 1, reptiles and fish plus all the supporting content related to those concepts. *Lesson 3* will contain all the remaining organizing and supporting content on the first level of elaboration, and so on. Figure 6 shows an incomplete example of the results of this step.

Step 7. Sequence All Content within Each Lesson

This step entails sequencing all the organizing and supporting content within each lesson. The following are the substeps to be followed:

7.1 Sequence the organizing content according to the following rules:

a. teach a superordinate concept before its parts or kinds;

b. teach the concept which is easiest and most familiar to students first; then gradually progress to the more difficult and less familiar concepts;

c. teach the concept which is most important first; then gradually progress to the less important concepts;

d. use the teachers' intuition and experience to decide upon the best sequence.

7.2 Sequence the supporting content (with the exception of learning prerequisites) according to the following rules:

a. if the supporting content is highly similar or interrelated from one concept to another, present all of it after all of the organizing content; otherwise, present each concept's supporting content directly after that concept;

b. teach the content which is easiest and most familiar to students first; then gradually progress to more difficult and unfamiliar content;

c. teach the most important content first; then gradually progress to the less important content;

d. teach superordinate supporting content before its subordinate ideas;

e. use the teachers' intuition and experience to decide upon the best sequence.

7.3 Sequence the learning prerequisites for all organizing and supporting content according to the following rule:

a. present each learning prerequisite as late as possible (i.e., present it just prior to the first time it is needed), unless considerable efficiencies can be realized by grouping highly related prerequisites together.

Step 8. Design and Develop the Micro-level Strategies

The instruction on each individual idea and fact should now be designed

and developed according to component display theory specifications (see Merrill, in press; Merrill, Reigeluth, & Faust, 1979; Merrill, Richards, Schmidt, & Wood, 1977). Test items are usually developed first for each idea and fact, and usually enough are created for use as practice items as well. Since most course goals call for students to be able

to apply or generalize what they have learned, the component display theory's *use-a-generality* prescriptions will usually be required for both test items and presentations. For test items, these prescriptions call for the use of new (previously unencountered) instances to which the generality must be applied, but those instances must still be within the domain of the generality.

For presentations, the use-a-generality prescriptions call for a generality, some examples, and some practice for each idea. The *generality* is a statement which applies to more than one instance. In the case of a concept, it is a definition of the concept (e.g., "A cold-blooded animal is an animal whose body temperature is determined by the temperature of its environment"). An *instance* is a single object, event, or symbol. In the case of a concept, it is an example of the concept (e.g., a snake could be presented as an example of cold-blooded animal). *Practice* is a question or statement which requires the learner to apply a generality to a new (previously unencountered) instance. In the case of a concept, it usually requires the student to classify something as to whether it is or is not an example of the concept (e.g., to classify a specific animal that he or she has never seen before as to whether or not it is a cold-blooded animal).

According to the component display theory, you should make sure that the examples and practice items are *different* from each other in as many ways as the student is likely to encounter in the real world, that they are arranged in a *progression* of difficulty from easy to difficult (which may include variation in response mode as well as manipulations of variable attributes), and are

clearly *labelled* as examples or practice.

Some concepts are more difficult for students to learn than others. If you expect a concept to be fairly difficult for the students, you should include a *larger number* of examples and practice items. You might also consider some additional techniques that can make the learning easier, such as an *alternative*

"The content of cognitive instruction is comprised of facts, concepts, principles, and procedures."

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representation (e.g., a line drawing or other kind of visual), and an *attention-focusing device* (e.g., underlining or color which high-lights important points). For more information about what these micro strategies are like and when they should be used in the design of instruction, see the papers by Merrill referenced above.

Step 9: Create the Synthesis Test Items and the Remaining Components of the Instruction

In addition to the synthesis test items, a number of components of the instruction remain to be developed for each lesson: the introduction, motivational strategies, internal summarizer and synthesizer, and expanded epitome. The following substeps can be used to accomplish this potpourri of activities:

9.1 Develop a large pool of *synthesis test items* for the lesson. Create a large enough pool of items to serve as practice items as well as items for several versions of the lesson test.

9.2 Help the teachers to plan an *introduction* to the organizing content (concepts) for each lesson. Such an introduction will often make use of an *analogy*, which relates what's about to be learned to something (outside of the content for this lesson) that the students already know. Encourage the teachers to try to think up an analogy or two that could help students to understand a group of related ideas. For more about when to use analogies, see Reigeluth & Stein (in press). Then the teachers should write the introduction for each lesson.

9.3 Have the teachers indicate the anticipated *motivational* needs for the instruction to meet, based on the nature of the subject matter and the students.

Then select and plan out an appropriate motivational strategy to meet each of those needs. For details about how to help the teachers to assess those needs and to select and plan out appropriate strategies, see Keller (in press).

9.4 Help the teachers to develop the *internal summarizer and synthesizer* according to component display theory specifications (that is, in generality-example-practice format). The generality for the summarizer is a concise statement of each idea and fact that was taught in the lesson. For the synthesizer, it is one or more subject matter structures (Reigeluth, Merrill, & Bunderson, 1978; Reigeluth & Stein, in press) plus the necessary verbal description to clarify their meaning. The examples for the summarizer are reference examples (i.e., highly typical, easy-to-remember examples), and for the synthesizer they portray the interrelationships among the ideas. The practice for the summarizer is a diagnostic, self-test item or two on each idea and fact that was taught, and for the synthesizer it is a set of diagnostic, self-test items on the interrelationships among the ideas.

9.5 Help the teachers to develop the *expanded epitome* for each lesson. The expanded epitome contains a *cumulative* summarizer and synthesizer for a set of lessons, and is also prepared according to component display theory specifications (see Reigeluth & Stein, in press, for details).

Summary

The nine steps discussed in this paper are summarized below:

Step 1. Decide to use a conceptual organization. Determine that knowing the "whats" (the concepts) of the subject matter is basically more important than knowing the "whys" (the principles) or the "hows" (the procedures).

Step 2. Select all the concepts to be taught and arrange them into kinds and parts conceptual structures. Have the teachers start with the most general and inclusive concepts and proceed to break each down into both kinds and parts until you reach the desired level of detail for the course. Check to make sure that all important, and only the important, concepts have been identified.

Step 3. Decide which of all the conceptual structures should be used as the organizing structure for the course.

Decide which conceptual structure contains the most inclusive and most important concepts in the course. See if two structures might be usefully combined into a matrix structure to provide an even more inclusive and important set of concepts.

Step 4. Allocate all concepts in the organizing structure to the levels of detail. Prune the organizing structure from the bottom up until you are left with a small enough amount of content (including supporting content) for a single lesson. Then allocate the next level of the organizing structure (the last level that was pruned off) to the first level of elaboration. Allocate each additional level of the organizing structure to the succeeding level of elaboration until all levels have been allocated.

Step 5. Identify the supporting content for each organizing content idea. Identify all other concepts (ones not included in the organizing structure), all principles, all procedures, and all facts that are highly related to the organizing content or to recently selected supporting content and hence are important to teach in this course. Also identify all learning prerequisites (for all organizing and supporting content selected so far) that have not yet been mastered by the target student population.

Step 6. Allocate all content within each level to lessons and sequence them. On each level of detail, group the most highly related organizing content together, along with its respective supporting content, in such a way that the total amount of content in each lesson represents the "optimal learning load" for the target student population and subject matter content.

7. Sequence all content within each lesson. First sequence the organizing content within a lesson, then intersperse the non-prerequisite supporting content, and finally intersperse the learning prerequisites, all according to

the rules described earlier.

Step 8. Design the test items and instruction on each individual concept, principle, procedure, and fact within each lesson. Design and develop the test items and presentations for each idea and fact within each lesson, using the prescriptions of the component display theory. For the ideas, this will usually mean generality-example-practice instruction whose level of richness is adjusted to the difficulty level of the idea in relation to student ability and experience.

Step 9. Create the synthesis test items and the remaining components of the instruction for each lesson. For each lesson, design and develop the synthesis test items, the introduction (preferably with an analogy), the motivational strategies (based on an analysis of the motivational needs of the students in relation to the content), the internal summarizer and synthesizer (in the generality-example-practice format), and the expanded epitome (also in generality-example-practice format).

> "Teach the concept which is easiest and most familiar to students first; then gradually progress to the more difficult and less familiar concepts."

Table 1.
Glossary of Terms

Cognitive Strategy Activator — an instructional strategy component which either requests or forces the student to use a cognitive strategy.

Component Display Theory — a prescriptive theory for designing instruction on a single concept, principle, procedure, or fact.

Concept — a set of objects, events, or ideas that share certain characterics.

Conceptual Organization — a way of structuring (or sequencing) instruction based on relationships among concepts, such as their superordinate, coordinate, and subordinate interrelationships.

Epitome — a special kind of overview lesson which epitomizes (in the standard dictionary sense of the word) the remaining content. Specifically, epitomizing entails presenting a few highly representative ideas, and those few ideas are taught at the application level, which means that examples and practice are used in the epitome as well as generalities.

General-to-Detailed Sequence — a sequence of instruction that starts by presenting the more inclusive, more basic, more fundamental content, and proceeds to present ever less inclusive, less basic, less fundamental content, one layer at a time.

Learner Control — the capability of students to make instructional decisions. For example, learner control over pacing means that the students can decide the pace at which they learn. Learner control is largely implemented by formatting the instruction in certain ways.

Learning Prerequisite — a concept, principle, procedure, or fact that must be learned before a different concept, principle, or procedure can be learned.

Levels of Elaboration — the first level of elaboration is content that provides more detail about the content in the epitome; hence it should not be taught until after the epitome has been mastered. The second level of elaboration is content that provides more detail about the content in the first level of elaboration; hence it should not be taught until after its related first-level content has been mastered.

Macro Strategies — components of methods of instruction that relate to many related concepts, principles, procedures, and/or facts. Such components include different patterns of sequencing instruction and different types of previews and reviews.

Micro Strategies — components of methods of instruction that are used for teaching a single concept, principle, procedure, or fact. Such components include rules, examples, non-examples, mnemonics, visuals, practice, feedback, and easy-to-difficult sequence of examples and practice.

Motivational Strategy Component — a method for increasing the stu-

dents' desire to learn the content.

Organizing Content — the type of ideas whose interrelationships provide the basis for sequencing the major chunks of course content. It may be either concepts, principles, or procedures.

Organizing Structure — the knowledge structure around which the course is organized. For example, for a conceptual organization the organizing structure would probably be a taxonomy in which each concept is a kind of its superordinate concept.

Principle — a change relationship which is cause-and-effect or correlational and may be either deterministic or probabilistic.

Procedure — a set of ordered actions for achieving a predetermined goal.

Summarizer — a specific kind of review which provides a concise generality, a reference example, and some self-test practice items for each idea taught in the lesson.

Supporting Content — concepts, principles, procedures, and facts (including learning prerequisites) which should be taught in addition to the organizing content ideas. They support the learning of the organizing content.

Synthesizer — an instructional component which teaches interrelationships among the ideas that have been taught. It presents a subject-matter structure which shows the interrelationships, some integrated examples which illustrate the interrelationships, and some integrated practice items which require the student to use the interrelationships to solve new problems.

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Book Reviews

The Computer in the School: Tutor, Tool, Tutee, edited by Robert P. Taylor. New York: Teachers College Press, 1980. 274 pages, $14.95.

This book is a collection of articles and presentations by five prominent practitioners in the field of computers in education: Alfred Bork, Thomas Dwyer, Arthur Luehrmann, Seymour Papert, and Patrick Suppes. In his introduction to the book, Taylor provides a framework to help the reader categorize the uses of the computer into three areas: 1) Tutor, 2) Tool, and 3) Tutee. He suggests that all educational uses can be broken down into these three categories. The 'computer as tutor' presents subject matter, accepts student responses, reacts to the responses, and keeps track of how the student is doing. The 'computer as tool" uses the computer's various capabilities, such as calculation, word processing, graphics, etc., to relieve students and teachers of these tedious and routine tasks. The 'computer as tutee' helps the learner and the teacher "gain new insights into their own thinking" by 'teaching' the computer to do something. As Taylor points out, "extended use of the computer as tutee can shift the focus of education in the classsroom from end product to process, from acquiring facts to manipulating and understanding them." (p. 4).

The Computer in the School offers 19 articles, a selected bibliography from each of the authors, and an index. The editor himself admits that the selection of authors and the diversity of the book is limited. He feels that these limitations will help reduce possible confusion for those "approaching such a complex area for the first time."

Alfred Bork's first article, "Preparing Student-Computer Dialogs," deals with the planning of the dialog or 'conversation' between the computer and the learner. He describes various types of dialogs such as: 'tests,' in which the student receives immediate feedback from the computer; 'remedial,' in which the computer, after testing the student, provides assistance in those areas where the student is found to be weak; and the 'interactive problem,' in which the student is guided by the computer in solving a problem. In his second article, "Interactive Learning," Bork begins by saying, "We are at the onset of a major

> "A few of the topics discussed in this article are: individualization, student control of pacing, student control of content, testing as a learning mode, and student management."

revolution in education, a revolution unparalleled since the invention of the printing press. The computer will be the instrument of this revolution" (p.53). He explains that the computer will allow students to be participants rather than spectators in the educational process. A few of the topics discussed in this article are: individualization, student control of pacing, student control of content, testing as a learning mode, and student management. Bork also speaks to the changes that would be necessary in educational institutions to foster this type of education. In his final article, "Learning Through Graphics," Bork discusses the important role 'graphics' plays in the learning process and its utilization on computer systems.