CONTENT ANALYSIS VIA CONCEPT ELABORATION THEORY

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Early in my career as an instructional design consultant I took the position that my concern was *not* "what to teach?" but rather "how to teach?" During the past several years it has become evident that subject matter experts may know what there is to teach but that they usually do not know what to teach. It is even less likely that having decided what to teach they know how to structure and sequence this content for maximally effective acquisition on the part of the student.

Robert Gagné has probably had more influence than any other person on current methodology for structuring and sequencing instructional materials. His position has come to be called "cumulative learning theory" (Gagné, 1968). The construction of "learning hierarchies" is often standard procedure in many of the systematic approaches to instructional design and development.

The purpose of this presentation is to propose a distinctive alternative to learning hierarchies and the frequently used procedures for sequencing and organizing subject matter content which are based on this approach. For identification purposes our position will be called "concept elaboration theory" and the content structure proposed will be called a "concept elaboration network".

A Review of Learning Hierarchies

How does one construct a learning hierarchy? "Beginning with the final task, I found it was possible to identify . . . subordinate capabilities related to each other in an ordered way by successively asking the question concerning each task, 'What would the individual already have to know how to do in order to learn this new capability simply by being given verbal instruction?'" (Gagné, 1968b)

What is a learning hierarchy? "A learning hierarchy . . . represents . . . the most probable expectation of greatest positive transfer for an entire sample of learners concerning whom we know nothing more than what specifically relevant skills they start with." ". . . one is searching for subordinate tasks which will transfer positively to the learning of the task in question." ". . . what are these . . . capabilities that make up a learning hierarchy? . . . They are intellectual skills . . . not entities of verbalizable knowledge . . . one must carefully record statements of 'what the individual can do', and just as carefully avoid statements about 'what the individual knows.'" (Gagné, 1968b)

"How does one know of the order assigned to the skills in the hierarchy is correct? . . . A general guide to such ordering is one . . . in which sample responses are subordinate to chains or multiple discriminations, which in turn are subordinate to classifying which in turn is subordinate to using principles or rules." (Gagné, 1968b)

How is a learning hierarchy used to sequence instruction? "A learning hierarchy . . . in the present state of our knowledge, cannot represent a unique or most efficient route for any given learner." ". . . I am not sure that a learning hierarchy is supposed to represent a *presentation sequence* for instruction in an entirely uncomplicated way . . ." ". . . learners can acquire verbalizable knowledge, and even intellectual skills, from sequences of presentation that are altered in various ways from what may be considered 'highly organized'". ". . . regardless of presentation sequence, if one is able to identify the intellectual skills that are learned, he will find them to generate positive transfer in an ordered fashion." (Gagné, 1968b)

In spite of Gagné's statement that hierarchies are not necessarily devices for sequencing subject matter, as currently used in systematic instructional development they are frequently used to determine instructional sequence. A student is usually taught each capability in turn progressing upward through the hierarchy.

A second use of a Gagné-type learning hierarchy is as an organizing device for the student. Hierarchy diagrams are often represented on the lead page of instructional segments. The box representing the content of the segment is often shaded or marked in some other way supposedly to let the student know where he is in the structure of the content.

Based on the quotations above, the use of hierarchies for sequencing or representing content structure for the student may be unwarrented extrapolations of Gagné's original intentions. What is Concept Elaboration Theory?

Concept elaboration theory is first, a procedure for representing the content structure of complex subject matter. Second, it is a procedure for determining an optimal sequence for teaching complex subject matter. And third, it is a procedure for determining an optimal presentation strategy for complex subject matter. It was created specifically as a design tool for instructional development.

Concept elaboration theory was created for teaching subject matter which requires the student to use a set of interrelated procedures or principles to produce some kind of product or solve some class of problems.

The fundamental premise of elaboration theory is that the underlying principle should be taught first. A principle is a statement of relationship between two or more concepts and most often explains *why* some event occurs. The principle should first be represented in its simplest form and should be illustrated via the complete procedure which can be derived. A *procedure* is a series of steps which must be followed in order to cause some event to occur or to derive some solution. Procedures most often indicate *how* to cause some event to occur. There are usually many procedures which can be derived from a single principle. In other words, first teach the principle which is fundamental to the complex procedure to be taught. Second, illustrate this principle with the most restricted but complete procedure which can be derived. Third, introduce layers of complexity by elaborating (i.e., making more complicated) the procedures involved until the student can carry out the procedure in its most complex form.

Concept elaboration theory is based on several hypotheses. First, that understanding why an event occurs, the principle, facilitates learning how to cause an event to occur or to predict its occurrence, the procedure. Second, that learning a complete procedure that is limited in scope and then elaborating this procedure by adding dimensions of complexity is more efficient and effective than mastering each step of a more complex procedure before moving on to the next step.

How is a concept elaboration network derived?

Step 1. Identify the terminal task. This is the same as step 1 in developing a learning hierarchy. This task should be represented via a carefully stated objective or via the test item(s) which will be used to assess performance.

Example. In order to briefly illustrate this procedure, consider the topic, "the accounting cycle", one of the first units in an introductory accounting course.

Objective. Given a packet of business documents such as cancelled checks, invoices, etc., which represent all of the transactions of a business over an accounting period, set up a general journal and a general ledger, enter and post the transactions, make appropriate adjusting entries, and prepare a balance sheet.

Step 2. Specify the complete procedure which is necessary to cause the task event(s) to occur or to produce the task product(s).

Example. A complete specification of the accounting cycle would unnecessarily lengthen this presentation. The following may be sufficient to enable the reader to follow the example. In actually preparing a concept elaboration network, a more complete specification is required.

The accounting cycle is as follows: Basic business documents indicate expenditures and revenue received by the business. The transactions indicated by these documents are entered one-by-one usually in chronological order, in a General Journal. These transactions are later classified as to type and transfered to appropriate accounts in the General Ledger. At the end of a specified period of time the separate ledgers are totaled, a balance sheet prepared which summarizes business activity during the period. For most businesses this summarization is complicated because some of the supplies, or inventory purchased in a given period will not be used up or sold until another period. In order to have a meaningful balance sheet, these unused supplies or unsold inventory must be credited to the accounts. These are called adjustments. Adjustments are entered into the General Journal and thus transfered to the various accounts in the General Ledger in a manner similar to actual transactions. A balance sheet is then prepared which reflects these adjustments and hence provides a more accurate picture of business activity.

Step 3. Identify the underlying principle.

Example. The accounting cycle is based on the principle that equal amounts can be added or subtracted to both sides of an equation without changing its equality or balance. The fundamental equation involved is that:

Assets — Liabilities = Owner's Equity

If a business has $1000 in assets and has no liabilities, then the owner's equity is equal to $1000. The equation is in balance. Accounting procedures are designed to record business transactions in a way which will preserve this balance.

Step 4. Derive a procedure based on the principle which is simple as possible.

Example. The simplest procedure for our accounting example is as follows: Step 1 add up the assets. Step 2 add up the liabilities. Step 3 subtract the liabilities from the assets, the remainder is the owner's equity. Step 4 prepare a simple balance sheet to show the results. (Obviously one wants to use a very simple business to illustrate this simple procedure.)

Step 5. Identify the dimensions of complexity which when added to the simple procedure elaborate it until it becomes the complex terminal behavior.

Example. The following seem to be the dimensions of complexity for our "accounting cycle" example. For purposes of this paper they are considerably abreviated. In a real world application greater detail would be required.

Starting with the terminal task (1) If we consider a business which starts and stops, rather than continues, we can simplify the procedure by making adjustments unnecessary. (2) If we reduce the number of accounts from many separate accounts, which is a necessity of an

actual business, to a single asset account, a single liability account, and a single owner's equity account we can simplify the procedure by entering transactions immediately into one of these three accounts making a general journal unnecessary and making posting to a general ledger unnecessary. (3) If we merely list assets and liabilities rather than recording individual transactions we are back to our simplest procedure identified in Step 4.

Step 6. Identify levels of elaboration. For each level identify the task by specifying an objective or preparing a sample test (parallel to Step 1). For each level specify the complete procedure which is necessary to cause the task event(s) to occur or to produce the task product(s). (Parallel to Step 2)

Example. For level O (we call this the *epitome* because it is the simplest representation of the principle and the procedure which still represents the entire principle).

Objective. Given a list of the holdings and amount owed by a simple business, decide which are assets and which are liabilities, calculate the owner's equity, and prepare a simple balance sheet.

Procedure. Step 1 classify items as assets, liabilities or owner's investment or withdrawals; Step 2 add up the assets; Step 3 add up the liabilities, Step 4 calculate owner's equity; Step 5 prepare a simple balance sheet.

For level 1 (the first level of elaboration)

Objective. Given a limited number of transactions, enter them directly into single asset, liability, or owner's equity accounts and prepare a balance sheet.

Procedure. Step 1 prepare T-account ledgers for an asset, a liability and an owner's equity account. Step 2 enter each transaction into a debit column and a credit column in the accounts. Step 3 total the accounts. Step 4 prepare a simple balance sheet.

For illustrative purposes it is unnecessary to complete this example for all levels. The procedures provided for illustration are necessarily brief and hence incomplete. In an actual application considerably more detail is desirable.

Step 7. Based on the procedures itemized for the terminal level (Step 2) and the intermediate levels of elaboration (Step 3) identify the concepts, identities and operations involved at each level. Also identify how the principle applies at each level including any extentions which may be necessary in the underlying principle. Diagram the relationships involved.

Example. Figure 1 illustrates such a diagram for "the accounting cycle." The conventions used in this diagram are as follows: A *hexogon* is used to indicate an identity or set of identities. A *large circle* is used to indicate a concept. Concepts are included in the network only if a student must learn to classify newly encountered examples and nonexamples of the concept in order to use the operation. Concepts which the student is assumed to know are not included.

A *small circle* is used to indicate a productive operation. Descriptive operations are not included in the network. It is understood that each concept in the diagram can be defined via domain concepts (attributes) and an appropriate descriptive operation.

Arrows are used to link domain concepts and identities to an operation and to link an operation to the resulting range concept(s). A given concept might be required by more than one operation. A range of one operation might be the domain for a subsequent operation.

Dotted lines are used to connect identities, concepts, or operations which are required in some modified form at a more complex level of elaboration. *Dashed concentric circles* are used to indicate levels of increasing complexity.

The terms used in defining these conventions are defined elsewhere. A repetition of these definitions in this paper would unnecessarily lengthen this presentation. (See Merrill and Boutwell, 1973; Merrill, 1973; Merrill and Wood, 1974; and Merrill and Wood, 1975).

In Figure 1 level O indicates that the students must learn to classify instances of three concepts: assets, liabilities, and owner's equity. Further $P1_0$ is the procedure for adding these separate quantities and displaying them via a simple balance sheet.

At level 1 the three concepts have been modified to include transactions classed as to assets, liabilities, or owner's equity. Also debit and credit conventions have

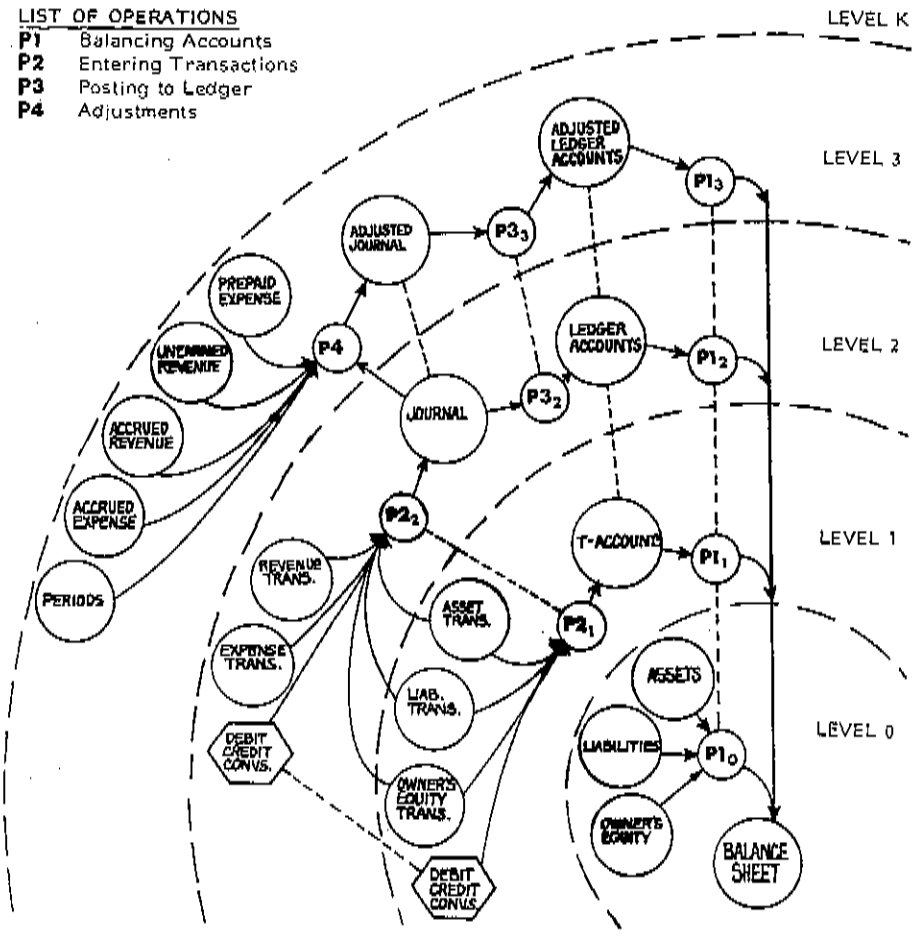

Figure 1. A concept elaboration network for accounting.

been introduced. P2 is the procedure for entering individual transactions into T-accounts. $P1_1$ (which is similar to $P1_0$) is the procedure for totaling accounts and producing a balance sheet. Space prevents our describing the whole diagram.

How is a Concept Elaboration Network Used to Sequence Instruction?

A sequence based on a concept elaboration network consists of an alternating series of integrated and segregated presentations. Starting with level 0, an integrated presentation involves (1) the presentation of the underlying principle and (2) a demonstration of the simple procedure with a specific example while showing the relationships of the procedure to the principle.

Following the integrated presentation (which we call the epitome) each of the separate concepts involved are taught using the rule, example, practice procedures which have been described elsewhere (Merrill & Tennyson, 1977; Merrill, Richards, Schmidt, & Wood, 1977). These rule, example, practice displays constitute a series of segregated presentations.

The epitome is then reviewed and the student is asked to practice the integrated procedure using new examples. This integrated, segregated, integrated cycle is repeated for each level of elaboration. For level 1, the underlying principle is again stated, extended as may be necessary for the new level of elaboration. The elaborated procedure is then demonstrated with a specific example while the steps are explained via the underlying principle. This integrated presentation is followed by segregated presentations for each of the new component concepts. These segregated presentations are followed by integrated practice, and so forth, to expanding levels of elaboration until the student has acquired the task at the terminal level of elaboration.

Summary

This presentation has been necessarily brief. Adequate instruction in the use of elaboration theory as in preparing a learning hierarchy requires considerable practice and can hardly be adequately taught in a short paper. Nevertheless, we have suggested that as used in instructional development for sequencing subject matter content learning hierarchies are a useful step in analysis of component skills but may not provide sufficient synthesis for sequencing instruction in complex interrelated procedures and principles. Concept elaboration theory has been suggested as a more adequate design tool for structuring, sequencing and determining presentation strategies for such complex subject matter. The premise of elaboration theory is that the underlying principle should be taught first accompanied by the simplest complete procedure. This initial presentation of the *epitome* should then be elaborated with an alternating sequence of segregated and integrated presentations which enable the student to learn the component concepts and to put them together in integrated practice. Each cycle of elaboration introduces more complexity until the student has acquired the terminal procedure.

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