31. GENERATIVE LEARNING: PAST, PRESENT, AND FUTURE

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31.1 INTRODUCTION*

Over the past 20 years, attention has gradually shifted from investigating the effects of the external, physical form of *instruction* to examining what internal processes of *learning* are stimulated or induced by external stimuli. As a result, models and prescriptions for learning are founded on theoretical and empirical evidence about cognitive functioning, processes, and structure of memory (see 5.4). Using this foundation, designers develop a conception of what occurs within the learner, and use this conception to guide designs of learning rather than instructional environments. While instructional and learning environments both contain facts or data points (information with which learners interact), the key difference is who does what with that information. In a learning environment, the learner and his or her learning processes, styles, and activities take on prime importance. A learning environment is not devoid of instruction or an instructor, but rather the external stimuli simply take on a secondary role. In an instructional environment, the role of learner and instruction are reversed.

Generative learning theory and its companion model of generative teaching is one such significant area of investigation whose theoretical foundation lies in neural research, research regarding the structure of knowledge and cognitive development, and whose focus is on the learner. This chapter defines generative learning and its foundation, reviews relevant research that tested the theory, describes the generative model of teaching and implications for instructional design, and concludes with a discussion of future directions for research.

31.1.1 Generative Learning Defined

Wittrock (1974a, 1974b) initially conceived of the model of generative learning that integrated several areas of cognitive psychology (see Chapter 5), including cognitive development, human learning, human abilities, information processing, and aptitude treatment interactions (see 22.3.3). His work stems from an attempt to explain and prescribe teaching strategies to maximize reading comprehension. While most of the original research deals specifically with reading comprehension, in theory there is much transferability to learning for understanding in general, regardless of the medium or form of the external stimuli. This article embraces the broader interpretation of this theory and model of learning.

From his initial conception to now, Wittrock emphasized one very significant and basic assumption: The learner is not a passive recipient of information; rather she or he is an active participant in the learning process, working to construct meaningful understanding of information found in the environment. The importance of asking the learner to generate his or her own meaning is clearly summarized by Wittrock's statement that "although a student may not understand sentences spoken to him by his teacher, it is highly likely that a student understands sentences that he generates himself" (Wittrock, 1974b, p. 182). It is as Harlen and Osborne (1985) call it, "learning through the person" (p. 137).

While there are and have been four parts to his model, I find it interesting that in his current writing, Wittrock (1990, 1991, 1992, 1993) explains more thoroughly his second essential attribute, which he feels distinguishes his from other theories and models of learning. He elaborates on the importance of and difference between two types of learner-generated *relationships*: first, among the different parts of the information that are being perceived and, second, between that information and the learner's prior

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*Recognition and appreciation are extended to Eileen Schroeder for her insightful comments on this manuscript, and to Christopher P. Rynd for his editorial assistance.

knowledge and other memory components. Comprehension occurs by formulating connections, rather than solely by the function of "placing" information or "transforming" information in memory. The subtle difference lies in the *creation of new* understanding of the information by the learner, rather than *changing* the presented information. (An analogy characterizing these important and subtle differences is presented in the next section in which generative learning is compared with other theories.)

These two combined attributes comprise only one of the four parts of his generative-learning theory, namely, the processes of generation. The three other component processes that explain learning are motivational processes, learning processes, and knowledge creation processes. Metacognitive processes also play a key role in his model, although in most cases he folds this idea into the learning processes component.

The concept maps portrayed in Figures 31-1 and 31-2 are illustrative of generative learning in action. These figures represent my comprehension of the ideas presented in Wittrock's (1974a, 1974b, 1985, 1990, 1991, 1992) writings regarding the progression of generative learning from neural brain processes research to models of thinking and teaching. The lines depict personally generated relationships between different concepts and ideas presented in his writings.

As shown in Figure 31-1, Wittrock conceptualized this model of generative learning based on a neural model of brain functioning and cognitive research on the process of knowing. From this foundation, the four components of the model are presented in shaded, rounded-corner rectangles with examples of each process presented as ovals under each. For example, "Attribution" is one example of motivational processes, and "Preconceptions" is one example of the knowledge creation processes. The process of generation is divided into the two types of possible relationship creations—between different parts of the information in the text and between the information in the text and prior learning and experience. This figure also implies a flow between the four processes of the model, with motivational processes activating learning processes, which in turn affects whether the process of generation will occur. The knowledge creation processes also affect the process of generation, but in a different way: Beliefs, preconception, prior concepts, and metacognition influence the quality and type of links that are created. Depending on the type of relationships generated, the four components converge for the purpose of learner-constructed reorganization, elaboration, or reconceptualization of the information to result ultimately in comprehension, as shown by the hexagons. Each of these processes will be discussed in detail later.

Figure 31-2 denotes the research by Luria (1973), as described by Wittrock (1992), on which generative learning was founded. As depicted here, Luria identified three functional units of the brain that are activated through the ascending and descending reticular activating systems and the frontal lobes of the cortex. In each of these units, responsibility for cognitive functioning originates, which then activates or manages one of the processes of knowing, which then influences one of the four components of Wittrock's generative-learning model—again depicted by the shaded, rounded rectangles.

The first unit, arousal and intention, influences an individual's learning processes and motivation. External stimuli arouse attention through the ascending reticular activating system. Without active, dynamic, and selective attending of environmental stimuli, it follows that meaning generation cannot occur regarding that environmental stimuli. The influence of arousal on attention flows from the environment outside of the learner, but interacts internally. Intention is activated by the descending reticular activating system, which stimulates attribution and interest. Attribution and interest influence the motivation of the learner. Attribution of effort, or the process of giving credit for success or failure to one's own effort, can influence whether or not the learner will exert the effort to be "attentive to the underlying structure of the information to be learned" (Wittrock, 1985, p. 123) and thereby become actively involved in generating understanding. If the learners attribute success to themselves, it follows that motivation to exert effort will be greater than if they attribute success to external forces (Weiner, 1979). The influence of intention on motivation for meaning generation flows from within the learner.

The second functional unit is the unit for receiving, analyzing, and storing information. The coding of information is managed by the frontal lobes of the cortex. The functions of the brain in this unit are influenced by the knowledge creation processes. Wittrock identifies many parts to the knowledge creation processes in several of his writings. Primarily, he includes beliefs, concepts, preconceptions, metacognitions, and experiences (see Fig. 31-1.). In other words, these are the components of memory. It is between these existing beliefs, concepts, preconceptions, etc., and environmental stimuli that relationships are formed and, thereby, understanding and comprehension are generated. According to Wittrock (1974a), "cognitive theory implies that learning can be predicted and understood in terms of what the learners bring to the learning situation, how they relate the stimuli to their memories, and what they generate from their previous experiences" (p. 93).

The third functional unit is the unit for planning, organizing, and regulating cognition and behavior. This unit operates through the frontal lobes of the cortex to coordinate learning and integrate information. These are the processes of metacognitive monitoring and generative processes—the heart and soul of generative-learning theory. By generating relationships between parts of what the learners see and hear, and by integrating that information with what exists in memory, learners reorganize, elaborate, and/or reconceptualize information, not simply "stuff in more information." It is a process for which meaningful understanding and comprehension are predicted outcomes. (see Fig. 31-1.)

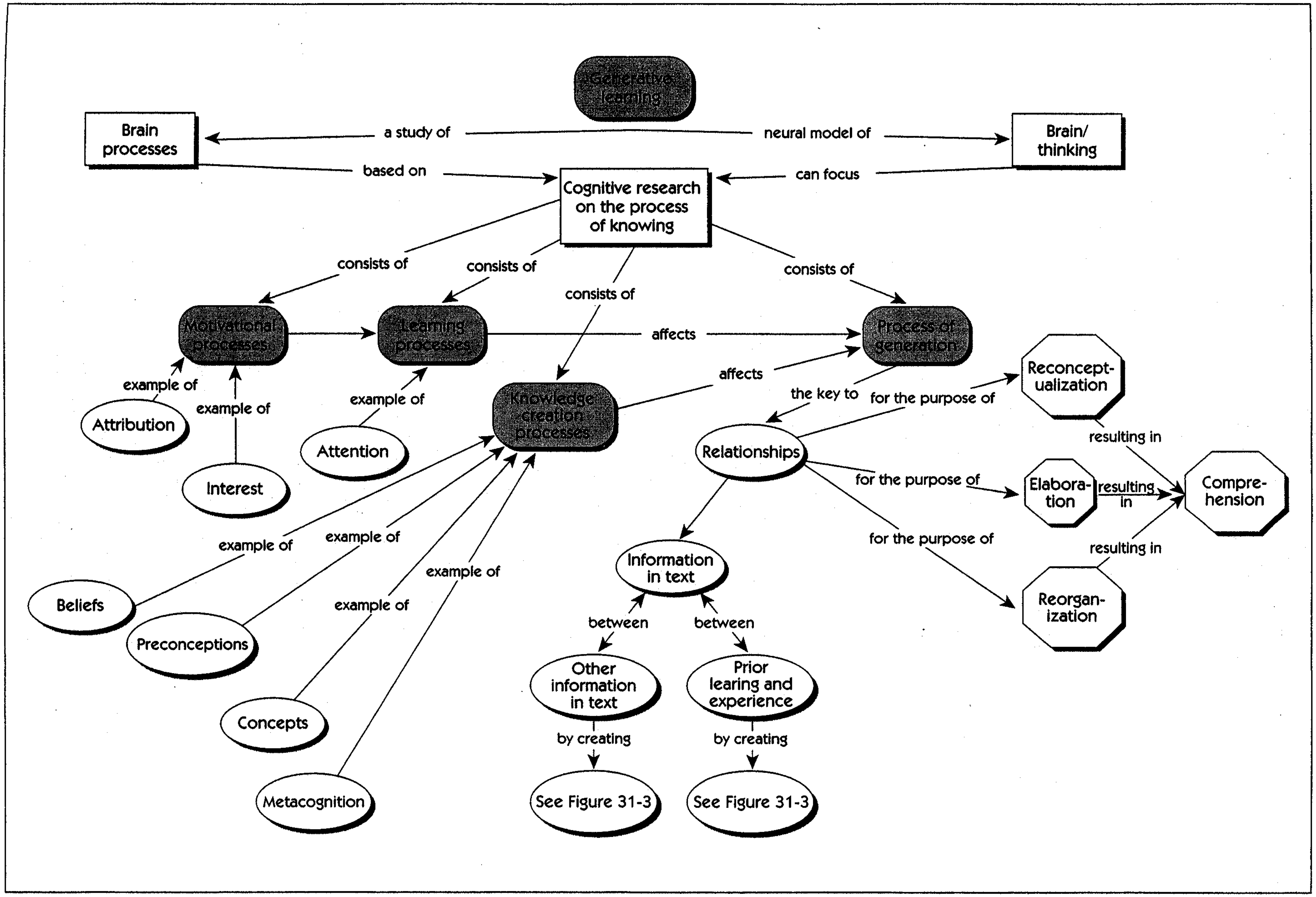

Figure 31-1. Generative-learning concept map.

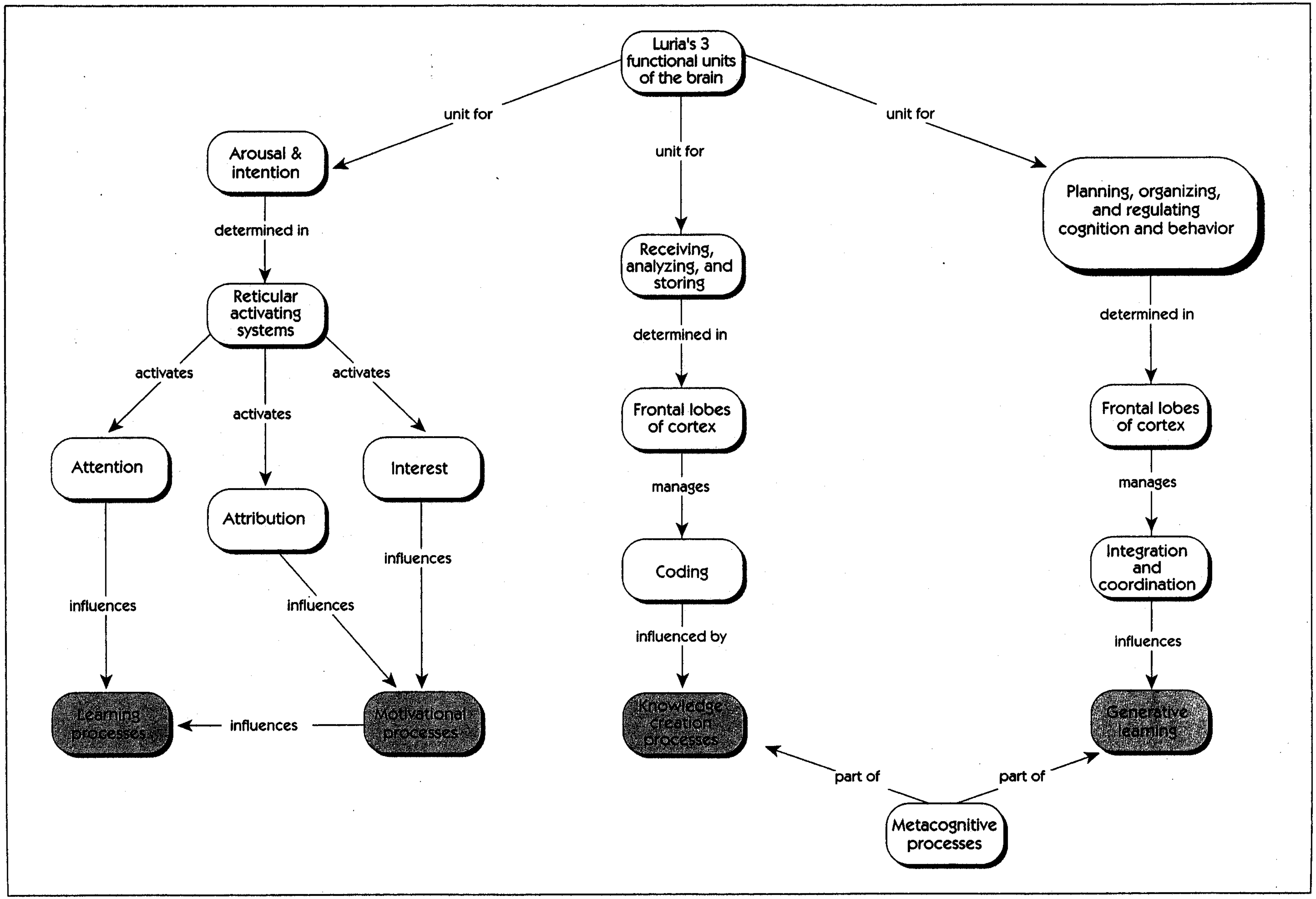

Figure 31-2. Neural functions concept map.

Wittrock (1990) claimed that there are two types of activities that can be judged as generative. Activities that generate organizational relationships between different components of the environment include "titles, headings, questions, objectives, summaries, graphs, tables, and main ideas," while those that generate integrated relationships between the external stimuli and the memory components include "demonstrations, metaphors, analogies, examples, pictures, applications, interpretations, paraphrases, and inferences" (p. 354). In Figure 31-3, those examples are shown in the ovals connected to one of the two types of relationships. From other activities proposed by DiVesta (1989), Goetz (1983), and Jonassen (1986), concept maps, diagrams, outlines, and identifying scripts within narratives seem appropriate to be added to the organizational relationship list. Mnemonics, clarifying, and predicting seem appropriate for his second, the integrated relationship list, linking external stimuli to internal components of memory. Notetaking, diagrams, and concept maps could be appropriate for both lists, depending on which cognitive processes were used to create which type of link—organizational or integrative. That is, if learners were only relating different ideas extracted directly from a text passage, together it would be classified as organizational, whereas if they related the information to prior knowledge, it would qualify as integrative. Figures 31-1 to 31-3 represent organizational maps. Table 31-1, shown in the next section, portrays generation as integration by reconceptualization and elaboration.

Only those activities that involve the actual *creation* of relationships and meaning would be classified as examples of generative-learning strategies. Restructuring or manipulation of environmental information presented to the learner by definition requires him or her to generate either organizational or integrated relationships and constructed personal meaning, thereby qualifying as a generative activity. If this activity were simply tracing with no generation of relationships or meaning apparent, rather than involve new positioning, the activity would *not* qualify as a generative activity. Other controversial activities such as highlighting or underlining can be argued as *not* being generative, since the activity involves examining only single components, even though the learner may be selecting author-written main ideas. Even if the learner is integrating the sentences with prior knowledge, there is no covert evidence of that integration, as the focus of the activity is a selection task in which he or she is simply selecting from among many parts. An activity must involve *meaning making* in order to qualify as generative. An activity in which the learner simply selects sentences that someone else has already composed cannot be considered a generative activity. The generated main idea *relates* all or some of the ideas presented in the passage together. If learners are relating the textual information to their own prior experience, knowledge, or preconception, however, it could be argued that highlighting or underlining would be generative. As will be seen in the applied research section, Rickards (1979) would support this notion.

31.1.2 Relationship of Generative Learning to Other Schools of Thought

Wittrock (1991, 1992) often compares his own theory with other theories. These comparisons are quite useful for understanding the nuances of his teaching recommendations. In Table 31-1, by depicting an integrative restructured elaboration, generative-learning theory is compared with other contemporary schools of thought: behaviorism, connectionism, schema theory, information processing, and constructivism.

These schools of thought differ in many ways, the most significant being what unit of analysis is examined and explained, and how thinking and learning are defined and exemplified. These basic differences are often subtle, yet they contribute directly to the type of model that has been constructed and the implications that are drawn for instruction. The purpose of this section is not to describe each of these theories in detail (see other chapters for further description); rather, it is to discuss overall salient differences between the various models and generative-learning theory and what these differences imply for instruction. The last two rows of Table 31-1 depict those differences, one directly, and the other in an analogical reconceptualization.

Of all the theories, behaviorism (see 2.2; Skinner, 1990) presents the most extreme difference from generative learning. That difference lies in how the role of the learner is perceived and what this perception implies for learning. For generative learning, the learner is the key—the controller of whether information is learned or not. Understanding all of the neural processes that affect learning, from intention to components in memory to attribution, will aid the designer in selecting or creating appropriate activities that take these factors into account when encouraging the learner to code or integrate information. The learner must also be actively and consciously relating ideas. For behaviorism, the learner plays no role, except as a passive recipient of information. The behavioral design of instruction must center on creating a stimulating message that reinforces by positive or negative feedback. Higher-level coding or integration is irrelevant in the prescription.

Connectionism (Wittrock, 1992) is similar to behaviorism, in that its intent is in strengthening associations. However, the network of individual memory is important, as in generative-learning theory. Connectionists, however, establish networks by strengthening associations by externally driven, repeated practice rather than creating personally drawn relationships between and among ideas. Understanding is internally created in generative-learning theory, making repetitions unnecessary.

Schema theory (Rummelhart, 1981; Rummelhart & Ortony, 1977) is similar to connectionism in that it deals with patterns of data points or schema. Basically, these data points form the knowledge units that are manipulated in generative-learning theory. Because of the way knowledge is stored, instructional and learning activities must connect new to existing knowledge so that it is easily retrievable.

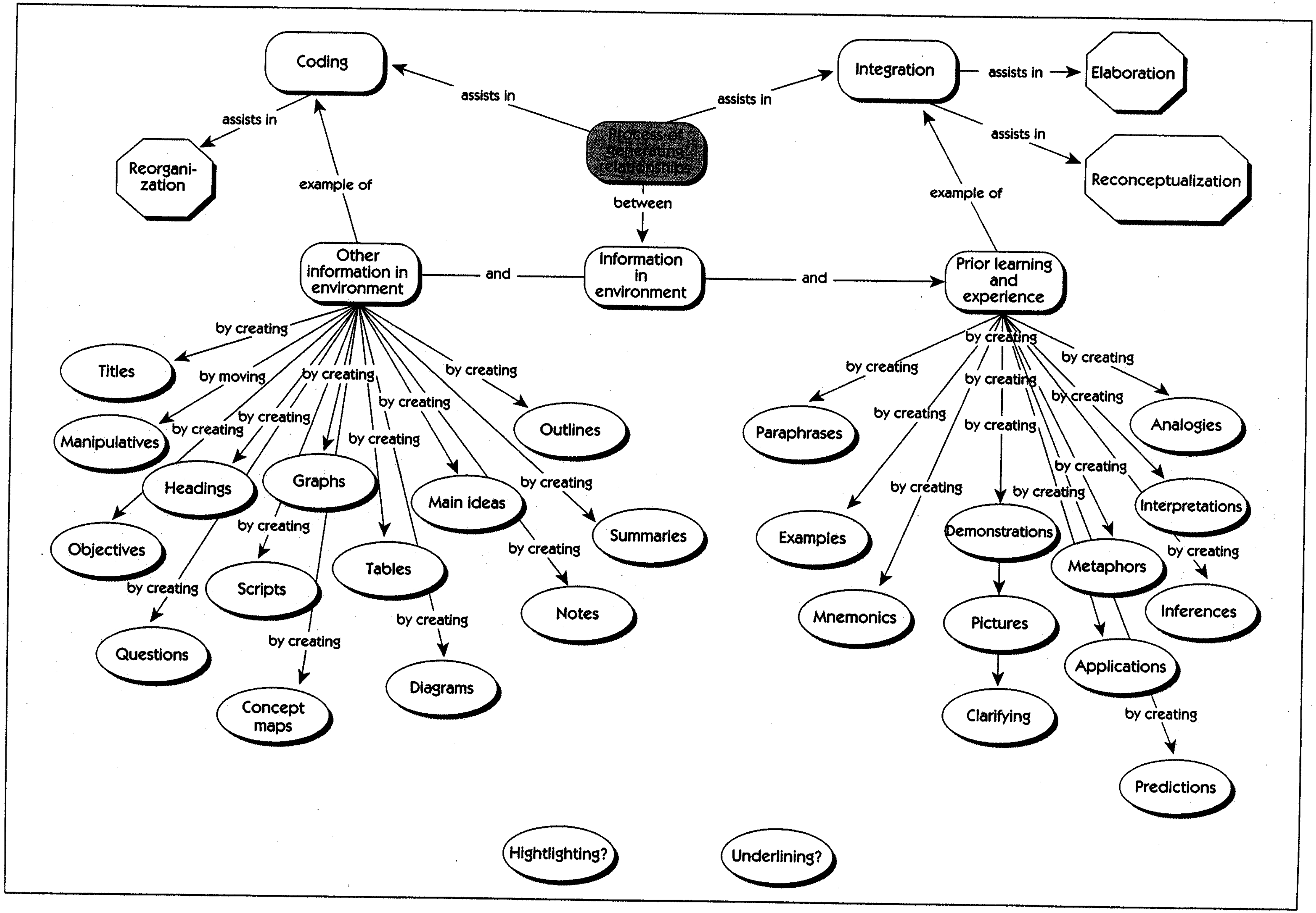

Figure 31-3. Generative activities concept map.

TABLE 31-1. COMPARISON OF RELATED SCHOOLS OF THOUGHT

Comparison	**Generative Learning Theory (Wittrock, 1992)**	**Behaviorism (Skinner, 1990)**	**Connectionism (Wittrock, 1992)**	**Schema Theory (Rumelhart, 1981)**	**Information Processing (Bell-Gredler, 1986)**	**Constructivism (Jonassen, 1990)**
A study of:	brain as controller	neural connections	memory associations	knowledge representation in memory	stages and levels of processing	philosophy of constructed meaning
Learning defined by:	learner-generated relationships	behavioral change	associations	creation of, addition to, restructuring of, or fine-tuning of schema	process of encoding information for retrieval	individually constructed understanding
Type of thinking:	brain as model builder by controlling the 4 processes	automatic paired response in S-R chain	neurally induced	schemata construction and reconstruction	transference of external stimuli to memory so it may be retrieved	building understanding from experiences
Levels of thinking:	comprehension/ understanding—coding, elaboration, reorganization, reconceptualization	unnecessary unit of analysis	conceptual	comprehension	rehearsal, coding, organization, conceptualization, integration, and translation	unspecified
Type of model:	neurally controlled learning	stimulus-response chains	subconceptual network model of memory	structural (networked) knowledge representation of memory	representation of the sequence of mental operation and form of stored knowledge	n/a
Components of the theory:	4 processes: motivation, learning, knowledge creation, and generation	operant conditioning, response formation, shaping, reinforcement schedules	networks of patterns and weights of nodes and connections	schema, schemata, scripts, and plans	stages: sensory receptors, short-term store, working memory, long-term memory; levels: deep and surface processing	source of reality, learner as builder
Implications for instruction:	activities that guide (induce) mental processes relating information	careful construction of the physical form of messages with repeated, rewarded practice	activities that strengthen connections through repetition	activities that relate new to existing knowledge so it is easily retrievable	activities that activate attention, facilitate processing in working memory, and facilitate transfer into long-term memory	creation of a contextualized learning environment

TABLE 31-1. *Continued*

Comparison	**Generative Learning Theory (Wittrock, 1992)**	**Behaviorism (Skinner, 1990)**	**Connectionism (Wittrock, 1992)**	**Schema Theory (Rumelhart, 1981)**	**Information Processing (Bell-Gredler, 1986)**	**Constructivism (Jonassen, 1990)**
Comparison with generative-learning theory:	n/a	claims a very different role for the learner, as passive recipient rather than active generator	explains learning as external neural induction instead of being neurally controlled internally; externally imposed not necessarily personally relevant	explains the basic knowledge unit used in generative learning theory	explains learning as a transformation of information rather than generation	Provides a philosophical basis rather than a neurological explanation of learning
Comparative analogy—task: purchasing clothing for an outing	*approach:* active and conscious selection of items	*approach:* passive and reinforced by salesperson	*approach:* passive, externally driven	*approach:* not specified, but rather the units of clothing that can be chosen are more representative here	*approach:* active but not necessarily internally controlled—represents the process one goes through from attending to those items in the store, to trying various combinations, and then taking them home to store in the closet using a variety of grouping strategies	*approach:* active—represents a philosophy that what is fashionable is constructed by individual tastes rather than predefined combinations proffered in society
	item purchased: the intent is creating a *new* fashion statement	*item purchased:* outfit selected and laid out by another	*item purchased:* selection of combination of items for outfit determined by those most commonly seen on peers or in magazines	*item purchased:* something to add to an existing outfit, tailoring of an old item, or creating of a new combination of items	*item purchased:* something to add to an existing outfit, tailoring of an old item, or creating of a new combination of items	*item purchased:* that which has been created by the individual rather than the salesperson

This connection is made by adding information to schema, restructuring, or tuning it. While connections are made by links, those linkages are not defined or labeled, as in creating a pattern note without labeling the lines. Generative-learning theory, on the other hand, is similar in concept to creating a pattern note with all the links labeled. Activities designed by schema theorists would include those that reminded learners of prior knowledge and related the information to what the learner already knows. It is less relevant who selects those connection points over the fact that they *are* made.

Information-processing theory (Bell-Gredler, 1986) explains the process of thinking and memory storage (see 5.4.1)—in other words, the stages and levels of processing. What we get out of information-processing theory is an emphasis on how we think, rather than on what we think, or that we think. Its focus is on that process of transforming external stimuli into some recallable form to be stored in memory. The emphasis of generative-learning theory is on the generation of *new* conceptual understandings, not just on transforming information.

Finally, constructivism (Jonassen, 1990) is a philosophy that underlies learning (see 7.3). It parallels generative theory in considering the learner to be an active processor of information; however, it is extreme in its position about the nonexistence of an objective reality. Wittrock has not addressed this notion in any of his writings.

To explain some of these subtle differences, a comparative analogy of an individual tasked with purchasing clothing for an outing was generated showing how the approach to the task (the purchase process) and the ultimate outcome (what item would ultimately be purchased) differ between schools of thought. The approach in generative buying would be exemplified as a buyer-controlled activity, with intention, motivation, and prior conceptions and beliefs about the outing and the people invited driving what types and styles of clothing are perceived as needed. The generative buyer would purchase cloth and create a *new* style based on those internally stimulated factors. The salesperson will query the buyer on how each article fits with those other influences, and how the articles would go with other items the buyer had at home. This buyer seeks a totally new fashion statement, rather than one already prepared.

A behavioristic example is simple: In a salesperson-driven environment, the approach is very passive with an outfit having been preselected, and the salesperson giving much praise and lauding for purchasing the item. In a connectionism scenario, the approach is also passive. Choices are driven by society-defined fashion that have been repeatedly seen (connected) in fashion magazines, television, and on peers. A buyer would purchase an outfit based on the frequency of seeing the outfit in fashion magazines. Intention or personal conception would already have been programmed.

Following schema theory, the buyer and seller play equal roles. Though the approach is not specified by this theory, the articles of available clothing in the store and at home will play the key role. How these articles are combined is the important aspect of this theory. Accessories could be added, items rearranged, the outfit tailored to reach different desired effects. The coordination factors, however, would remain undefined. Intention, personal conceptions, or the generation of some new fashion item are irrelevant.

For information processing, both the buyer and sales environment are essential players, meaning that the approach by the buyer is active, but not necessarily internally controlled. The information-processing buyer would attend to featured items that catch his or her attention, select a few, try on various combinations, and purchase a standard outfit, embellish it with accessories, or ask for it to be tailored. The key difference here is that what is purchased is transformed from a rack in a store into an appropriate outfit following established rules of fashion, rather than generating totally new fashion statements or a totally new garment from different pieces of cloth.

A constructivistic buyer would hold a philosophy that what is fashionable is constructed by individual tastes and needs rather than predefined combinations proffered by society. The approach would be very active, independent, and individually driven. The ultimate item or combination of items would make an individual statement.

In each case, the notable difference is in the role of the buyer (learner) as he or she is related to the salesperson (instructor) or store items (instruction). This is exemplified through the approach (learning process) taken to the task, and the final selection of the item (learning).

31.2 APPLIED RESEARCH

Studies investigating the viability of the generative model of learning have tested the effects of simple coding strategies such as underlining, notetaking, and adjunct or inserted questions; more complex coding/organizational strategies such as creating hierarchies, headings, summaries, and concept maps, or the manipulation of objects; elaborative integration strategies such as imaging, and creating examples, interpretations, or analogies; and, finally, metacognitive generative-learning training. Table 31-2 organizes and summarizes some of the most significant work testing Wittrock's theory. The table divides the types of research into those that represent a coding generative activity and those that represent an integrative generative activity. Those that exemplify coding interrelate concepts from the instruction together to create one level of understanding through various levels and types of organizational activities. Those exemplifying integration interrelate the concepts from the instruction with prior knowledge to create a higher level of understanding by reconceptualization and elaboration. A discussion and summary of the results from each of these areas is provided. This discussion begins with the most controversial—underlining—so that it neither gets lost among the other significant, noncontroversial

TABLE 31-2. SUMMARY OF SELECTED APPLIED GENERATIVE RESEARCH STUDIES

Generative Activity	Author/Year	Dependent Variable	Content	Age Level	Results
Coding—Underlining?					
underlining	Rickards & August, 1975	reading comprehension	educational psychology	college students	Increased achievement on posttest when learner underlined most relevant information.
Coding—Notetaking					
notetaking	Peper & Mayer, 1986	recall, problem solving	auto engines	high school & college students	Notetaking increased achievement for far-transfer problem solving but not near-transfer fact retention.
notetaking	Shrager & Mayer, 1989	recall, problem solving	how to use a camera	college students	Confirmed above findings, also significant differences for students with low prior knowledge.
notetaking	Barnett, DiVesta & Rogozenski, 1981	immediate and delayed recall	history	college students	Notetaking produced better results than no notetaking, but no significant difference between elaborated review and simple review of notes. Review of instructor-prepared notes resulted in greater learning than review of learner-generated notes. Delayed retention scores higher for questions from learner notes.
Coding—Adjunct Questions					
adjunct questions: frequency, nature of, need for feedback, overt/covert responses	Anderson & Biddle, 1975	facts, motivation, and higher-order thinking	across content areas	across age levels	Better learning with more frequent questions. No difference if feedback is given. Overt response needed depending on if questions were embedded.
adjunct postquestions with no overt responses	Sutliff, 1986	facts, inference	electrical engineering	low- and upper-ability college students	No significant differences between groups.
adjunct questions super/subordinate postquestions	Burton, Niles Lalik & Reed, 1986	recall of main ideas and details	description of a mythical country	undergraduates	More main ideas were recalled. General questions were more engaging than detailed ones.
adjunct postquestions	Woods & Bernard, 1987	recall of intentional and incidental ideas	weather forecasting	adults—aged 60 or older	Adjunct questions aided recall of intentional ideas only.
adjunct pictures	Brody & Legenza, 1980	reading comprehension	history	undergraduates	Postpictures were more beneficial than prepictures.

TABLE 31-2. *Continued*

Generative Activity	Author/Year	Dependent Variable	Content	Age Level	Results
Coding—Organizational Strategies					
organization hierarchies	Wittrock & Carter, 1975	free recall	mineral tables	undergraduates	Learner-generated hierarchies for disorganized lists significantly better than simply reproducing them. Reproducing organized hierarchies significantly better than learner-generated ones.
organization headings, sentence meaning	Doctorow, Wittrock & Marks, 1978	reading comprehension	SRA literature	elementary school students	Learner-generated sentences combined with experimenter-provided headings produced increased comprehension followed by generative only.
organization -concept vs. semantic maps	Beissner, Jonassen & Grabowski, 1993	drawing, identification, terminology, comprehension, and problem solving	heart content	undergraduates	Learner-generated concept maps better strategy for holists. Learner-generated semantic maps better for serialists for problem solving learning only.
organization concept maps—learner generated vs. system provided	Smith & Dwyer, 1995	drawing, identification, terminology, and comprehension	heart content	undergraduates	Learners using instructor-provided concept maps performed better on identification tests only. No other differences found.
Coding—Manipulation of Objects					
physical manipulation of objects	Sayeki, Ueno & Nagasaka, 1991	calculating an area	math	elementary school children	Posttest showed physical manipulation facilitated problem solving.
mouse-manipulated graphics	Haag & Grabowski, 1994	terminology, identification, comprehension, and problem solving	heart content	undergraduates	Learner-manipulated graphics increased problem solving over static or computer-manipulated graphics.
Integration—Imaging					
imaging	Anderson & Kulhavey, 1972	prose learning	fictitious description of a tribe of people	high school seniors	Significant differences in favor of those who actually used an imaging strategy.
imaging— experimenter provided/ learner generated	Bull & Wittrock, 1973	recall of verbal definitions	definitions of nouns	elementary school children	Recall was significantly higher for imaging than verbal/copying strategy.
verbal and image elaborations: sequence	Kourilsky & Wittrock, 1987	economic understanding	economics	high school students	Verbal-to-image elaborations significantly better than image to verbal or either used singularly.
verbal only, image only, and combined elaborations	Laney, 1990	reasoning in decision making	economics	third-grade children	Verbal-only and verbal-to-image integrated strategies facilitated reasoning better than imagery only.

TABLE 31-2. *Continued*

Generative Activity	Author/Year	Dependent Variable	Content	Age Level	Results
Integration—Elaborations					
elaborations elaborated sentences	Stein & Bransford, 1979	retention	language arts	undergraduates	Performance facilitated only when elaborations clarified precise objectives—prompting encouraged subjects to ask more relevant questions.
elaboration examples	DiVesta & Peverley, 1984	concept attainment—near and far transfer	fictitious concepts	undergraduates	Students who generated their own examples did significantly better on far-transfer tasks than those given instructor-provided examples.
elaboration interpretation	Johnsey, Morrison & Ross, 1992	recall, recognition, application, type of elaborations	professional development	adults	Results favored the use of embedded vs. detached elaboration strategies. Elaborations better than no elaborations. No difference between leaner generated vs. experimenter provided.
Combination of Coding and Integration Strategies					
images, verbalization of the image and summaries, structural *adjunct questions*	Carnine & Kinder, 1985	reading comprehension	social studies and science	low-performing elementary school children	Comprehension increased significantly but not more than when inserted questions on passage structure were used.
summaries and analogies	Wittrock & Alesandrini, 1990	text	marine life	undergraduates	Summaries facilitated reading comprehension better than analogies, and both did better than reading alone.
summaries and analogies: alone and in pairs	Hooper, Sales & Rysavy, 1994	achievement, efficiency, and generations	marine life	undergraduates	Those who generated summaries performed better than those who generated analogies. Students working alone did better than those working in pairs.
combination of generative strategies—images, summary sentences, and analogies/ metaphors	Linden & Wittrock, 1981	factual retention and comprehension	reading	elementary school children	All generations increased and correlated with comprehension. More generations were produced when images were produced before verbal elaborations. No difference by generation sequence. Results were mixed for factual recall.
Metacognitive Processes					
generative learning processes training	Kourilsky & Wittrock, 1992	comprehension, confidence, misunderstanding	economics	high school seniors	Generative learning procedures significantly increased confidence and decreased level of misunderstanding.
generative teaching training	Kourilsky, 1993	comprehension, misunderstanding	economics	professional teachers	Pre- to posttest gains on both exams were significant when misconceptions were clarified and learning recovered.

studies nor is given the same importance of many of the other studies reported here.

31.2.1 Simple Coding

31.2.1.1. Underlining. As previously discussed, an argument can be made for the activation of generation processes in the learner by having her or him consciously and interactively relate information in the passage with prior beliefs and conceptions. This is, in essence, what Rickards and August (1975) did in their study. They investigated subject-generated versus experimenter-provided underlining strategies under six treatment conditions. Their results indicated that when college students had an opportunity to underline text that they considered most relevant, they performed much better on the posttests on both objective-specific and incidental learning (total recall). In fact, a very interesting result was that in the learner-generated condition, in which the subjects were asked to underline the least important items, they did poorest of all. Rickards (1979) explained that since learners were asked to underline those sentences that were more relevant *to them,* a mental interaction between sentences and between what they read and their own preconceptions had to occur, thereby establishing plausible evidence that learner-constructed generative learning occurred.

31.2.1.2. Notetaking. Notetaking is considered an organizational, coding strategy, which has some controversy connected with it as well. No generation of understanding occurs when a learner simply copies sentences from a page. As with the Rickards' argument, however, a learner that rewords sentences to combine ideas from the passage or relate them to prior knowledge is engaging in generative activity. This is an important distinction for teachers as they teach learners how to take notes and give them feedback in the process. To illustrate, three studies have been selected that include both high school and college students in both vocational and liberal arts areas.

Peper and Mayer (1986) found from two experiments, one with high school and one with college-level students, that notetakers performed better than non-notetakers on far-transfer tasks of problem solving but were worse on near-transfer tasks of fact retention and verbatim recognition (p. 34). Shrager and Mayer's (1989) study of college students instructed to take notes or not to take notes from a videotaped lesson confirmed these findings and found the effect on recall and transfer highest for learners with low prior knowledge. Peper and Mayer also tested the effects of other generative strategies, such as taking summary notes and answering conceptual questions during breaks in lectures, which produced similar results. This study points out the importance of examining the effects of generative strategies on the quality vs. quantity of learning.

Notetaking in two studies by Barnett, DiVesta, and Rogozenski (1981) was hypothesized to aid college students in the processing of information. Notetaking produced better results in learning from text than no notetaking, but elaboration of the notes during a review period, a generative activity, produced similar results in terms of amount of learning as those who simply reviewed their notes. An interesting dimension to this study was the inclusion of instructor-prepared notes vs. learner-generated notes. For immediate recall tests during which learners had an opportunity to review or elaborate on instructor-prepared notes, they performed better than the learner-generated notes group. A second study tested whether the effects were the same for different types of questions: those common to the group, those from their own notes, those from others' notes, and those from others' elaborations. Scores for the delayed test using questions from their own notes were dramatically higher than the other groups. This provides a strong case for notetaking causing generative effects. In other words, these results showed that learners remembered what they originally perceived and encoded versus what others had intended them to remember.

To summarize, at least with these studies, notetaking has shown positive effects, but there were mixed findings when compared with type of learning. Notetaking may be a highly generative activity; however, quality of notes, type of elaborations, and opportunity for review can affect what, how much, and for how long information is learned.

31.2.1.3. Adjunct or Inserted Questions. Adjunct questions have been classified by Wittrock (1990) as a generative activity. They function as a coding and organizational guide. While questions can be generated by the learner, Wittrock also believes that they serve a teaching function to induce generative thinking by causing the learner to organize the information presented by relating ideas from a passage together, thereby creating personally meaningful understanding.

Over the past 25 years, the effects of inserted or adjunct questions have been studied extensively across content areas and age levels. Two important reviews of this research have summarized those findings. Anderson and Biddle (1975) and Rickards (1979) have concluded that inserted postquestions have been shown to increase recall of incidental learning (where criterion questions are unrelated to the inserted questions) as well as increasing recall on intentional learning (i.e., where criterion questions are the same as the inserted questions). Prequestions have been shown to increase intentional learning only.

According to Anderson and Biddle (1975), adjunct questions have also been examined in terms of frequency, the need for feedback, the nature of the question, the need for overt responding, and motivation. They summarized that: The more frequent the questions the better; feedback increased learning, but so did inserted questions without feedback; while most of the research focused on fact-level questions, there was also a positive effect from higher-level questions; free recall was generally better than multiple choice; a need for overt responding was dependent on how the questions were embedded; and the questions did motivate learners in some cases. They also found that these effects held across age level, content, length of text, and medium used.

Sutliff (1986) investigated the effect of inserted questions on reducing passivity in a self-instructional slide-tape presentation as evidenced by increased learning of facts (direct learning) and inference (indirect learning). His findings were opposite those of Anderson and Biddle in that there were no significant differences between groups. He interpreted the nonsignificance to be a result of not requiring overt responses to the questions, again contrary to previous research. Because of this "veto power over learning," described by Rothkopf (1976, p. 94), results such as this need to be examined further to determine just where overt manifestations may be necessary to ensure that processing occurs.

Burton, Niles, Lalik, and Reed (1986) investigated the effect of superordinate and subordinate questions on the amount of mental effort (level of cognitive capacity engagement) by using a secondary task probe technique and a passage about a mythical country. They found that superordinate questions have a greater learning effect, and that the effect carries over into subsequent text. The overall result also indicated that more main ideas were recalled than details. The explanation of the effect offered was that superordinate information is pulled into short-term memory more frequently, so it gets more practice. In other words, they found that general questions are more mentally engaging than detailed ones.

Woods and Bernard (1987) also found effects contrary to those of the reviews of Anderson and Biddle and Rickards. They investigated the effects of adjunct conceptual postquestions for encouraging greater depth of processing of verbal information of adults 60 and older. From results on intentional and incidental free-recall tests, they found that adjunct questions helped older learners process only intentional text at a greater depth.

In an interesting twist of the research question, Brody and Legenza (1980) studied the effect on learning of inserted pictures as opposed to inserted questions and hypothesized that the effect would be the same as the results on adjunct questions. Their findings supported their hypothesis that postpictures were more beneficial to reading comprehension than prepictures.

To summarize the numerous studies: Postquestions and postpictures have been shown to be most effective for increasing both intentional and incidental learning; superordinate questions have been more effective than subordinate detail questions; and overt responses have been more effective than allowing covert responses.

31.2.2 Complex Coding

31.2.2.1. Organizational Strategies. This topic deals with a variety of coding/organizational activities including creating hierarchies, headings, and sentence meanings, and mapping techniques across all age levels from elementary school children to professionals in a variety of topics from science to language arts. These organizational tasks require learners to relate ideas from a passage together by using a variety of symbolic representations. Each addresses at least one of three key questions regarding the generative model of learning: the effect of learner-generated learning vs. the effect of learner-reproductive learning; learner-generated vs. instructor-provided constructions of meaning—including organization as a variable; or the general effects of generated elaborations.

Wittrock and Carter (1975) studied free-recall responses of undergraduates in generative vs. reproductive treatments using hierarchies with varying degrees of order. The generative group was directed to organize the hierarchies, while the reproductive group was directed to simply copy them. The results showed better performance for the generative treatment groups than for the reproductive groups for the disorganized and randomly organized hierarchies. However, the organized reproductive group performed better than the unrelated generative group. This means that organization in the stimuli can compensate somewhat for a lack of learner-generated strategies, but providing organization in the instruction *and* opportunities for generative activity will be the best.

In two experiments with elementary school children, Doctorow, Wittrock, and Marks (1978) studied the effect of learner-generated vs. experimenter-provided paragraph headings and sentence meanings on comprehension. Again, the combination of text organized through the use of headings plus learner-generated sentences about the paragraphs produced dramatic gains in comprehension and recall. Generative instructions without experimenter-provided headings followed as the next most effective, and paragraph headings alone were more effective than the control group. This strategy also increased comprehension more for high-ability students than for low-ability students, perhaps because high-ability students have better organizational cognitive abilities to make sense out of disorganized information.

Beissner, Jonassen, and Grabowski (1993) tested the effects of two organizational strategies against learner differences at four levels of learning. Their findings showed an interaction between learner-generated concept vs. semantic maps and serialist learners on the problem-solving questions only, with serialists performing better with semantic maps, and holists performing better with concept maps. While this study did not compare their results with instructor-provided maps, it does contribute evidence to considering the importance of learner cognitive strengths and patterns of thinking when selecting organizational learning activities.

Also studying the effects of concept maps, Smith and Dwyer (1995) found a significant difference only on lower-level terminology tasks in favor of instructor-provided maps. This result is consistent with that of Wittrock and Carter (1975). For lower-level tasks, organization helps, especially when a learner is tested with questions that show similarity to the organization that an instructor may have possessed when creating the test.

To summarize the findings of these studies: The results show that learner-generated activities are more effective in improving achievement than instruction-provided organizational schemes. Performance is increased even more when the text is organized. The selection of activities should be tempered by cognitive ability.

31.2.2.2. Manipulation of Objects. The next organizational activity deals with manipulating objects. While this activity extends beyond the printed page as designated by Wittrock's work, it qualifies as a generative activity because a relationship is being drawn and extended between parts of the environment.

Sayeki, Ueno, and Nagasaka (1991), in a very interesting study, investigated the effects of transforming mediational objects in the learning of mathematical principles. Their results supported the hypothesis that manipulatives would increase comprehension. While they do not specifically call this a generative activity, the act of creating understanding by generating both mental and physical relationships from different shapes of a manipulable rectangle manifests the same required attributes defined by Wittrock. Their results from mathematics should be tested for conceptual learning and problem solving in other content areas.

Haag and Grabowski (1994) extended this work to computer-manipulated graphics. Most applications of moving or manipulated graphics are done through generated animation. In this study, they found that learners who manipulated the graphics on the screen using a preorganized organizational framework increased problem solving over those using no organizational framework or having the computer create the graphic statically. These results are consistent with those of other organizational strategies reported in the previous section.

Both studies lend support to the use of manipulatives for generating understanding for both children and undergraduates in math and science.

31.2.3 Integration Strategies

The next series of studies examine the effects of activities that require a student to relate information to prior knowledge. In these activities, learners are integrating that information through imaging, elaborations, and analogies.

31.2.3.1. Imaging. The effects of imaging have also been investigated extensively with four of those studies summarized here. They include fictitious descriptions, language arts, and economics topics studied by elementary or high school students.

Anderson and Kulhavey (1972) studied high school seniors to determine the effect of imaging on prose learning. In this study, half of the subjects were told to image, while the other half were not. Results indicated no difference in prose learning between the groups. On further probing, the researchers discovered that not all of the students in the imaging group actually created images (only 50% did), and many in the control group did create images (about one-third)! Comparing those subjects from both groups who actually used imaging with those who did not showed significant differences in favor of the imaging strategy. This illustrates the fact that mental activity cannot be strictly controlled by instruction and, again, raises the issue that requiring an overt response may be more effective in encouraging the desired result than just simply providing direction to image, as Sutliff (1986) found with adjunct questions.

Bull and Wittrock (1973) compared the effect of experimenter-provided vs. learner-generated imagery with elementary school children. Groups were directed to either draw, trace, or copy verbal information on definitions they were to learn. As predicted, results showed that the group that generated images performed significantly better than those who copied definitions; however, there was no significant difference between the imagery provided (tracing) and the copied definitions groups.

Kourilsky and Wittrock (1987) investigated what effect the sequence of the use of verbal or imaging generative activities would have on economic understanding by high school students. They found that using verbal elaborations first, followed by imaging, significantly increased economic understanding. They also found significantly greater gains by using both generative activities (verbal and imaginal) over just verbal elaboration only.

Laney (1990) found a slightly different result. Examining economic reasoning in the decision making of third-graders, he found that the verbal-only and integrated strategies were more effective than the imaging-only strategy. While using both symbol systems increased learning in both studies, the verbal-only elaboration was more effective than both the imagery-only and the use of dual-symbol systems. He felt his results were consistent with Wittrock's notion that the effective use of imagery is developmental. Laney's third-grade subjects had not yet developed this ability and were more familiar with verbal instruction. These are important results given the confusion that could result from the use of a generative imagery strategy too early in a learner's developmental cycle.

These studies have shown that overt imaging is more effective than covert; learner-generated imaging is more effective than instruction-provided imaging; and visual images may be more effective than verbal ones, only in cases in which students have progressed developmentally to the point where they can understand them.

31.2.3.2. Elaborations. Stein and Bransford (1979) conducted two studies to determine the effects of learner generated or experimenter provided by type of sentence elaborations. They hypothesized that congruence of the elaboration with the topic would be the determining variable and, in fact, did find differences in two experiments with undergraduates. In those cases where elaborations were incongruent, students did worse than those in the treatments with no elaborations at all. Two important findings indicated that "elaborations facilitated performance only when they clarify the precise significance of target concepts . . . and that prompting subjects to ask relevant questions facilitated both the precision of elaboration and subsequent retention" (p. 769).

DiVesta and Peverley (1984), in a very complex study, tested learner-organized vs. preorganized examples on near and far transfer in a concept attainment lesson. Additional variables included variability of examples, and sequence. Their results on the active vs. passive element of their study indicated that students who generated their own examples did significantly better on both transfer tests than the preorganized group.

Johnsey, Morrison, and Ross (1992) investigated the effects of embedded vs. detached and learner-generated vs. experimenter-provided elaboration on recall, recognition, and application learning. The type of elaborations tested in this study in the area of adult professional development included two types of statements relating the content of the lesson to their job, and stating implications of the information presented to their job environment. When these elaborations were embedded in the CAI training, significant gains were found; however, there were no differences between the learner-generated or experimenter-provided elaborations. Teaching students how to generate elaborations at the time they will need them appears to be consistent with "just-in-time" training, especially when the technique may be new or more mentally difficult to implement.

31.2.4 Combination and Comparison of Coding and Integration Strategies

Carnine and Kinder (1985) expanded on the Anderson and Kulhavey study on imaging. In their investigation, elementary school subjects were asked to form an image, then verbalize it, and were then given corrective feedback. They were also asked to create a summary at the end. This strategy was compared to a "schema-based strategy" in which learners were asked structurally related questions about the passage composition. They found significant gains in reading comprehension from pre- to posttests for both narrative and expository text for both treatments. One cannot be sure whether the positive results were due to the additional instructional effects of the feedback. Nevertheless, the question of the need for feedback on learner-generated activities is an important one since significant differences favoring adjunct questioning over the imaging strategy were observed for learning of expository materials.

Linden and Wittrock (1981) conducted a study with elementary children that found that students who were asked to generate text-related summaries, analogies, metaphors, and pictures had better comprehension than those who were not. When instructed to generate images before verbal explanations, students produced more generations.

Wittrock and Alesandrini (1990) also investigated the effects of learner-generated summaries and analogies by analytic and holist undergraduates. The results followed the predicted rank ordering, with the most positive effects found for generating summaries, followed by generating analogies, both of which were significantly better than the control group, which contained no generative activities. They also found that individual differences of analytic and holist ability correlated with learning differently in the three treatments: analytic ability with learning in the generate analogies group, the holist ability with the text-only control group, and both analytic and holist abilities in the generate summaries treatment.

Finally, Hooper, Sales, and Rysavy (1994) tested undergraduates on achievement efficiency and generations when given summaries and analogies while working alone and in pairs. They found that those who generated summaries performed better than those who generated analogies. Contrary to expected predictions, students working alone did better than those working in pairs.

When using a combination of strategies, the difficulty of the task must be taken into consideration, and, where possible, the effects of cognitive strengths must be factored in. Imaging is a more difficult task than adjunct questions, and analogies more difficult than summaries. If learners are not developmentally ready for such a task, it may cause more frustration than positive effects.

31.2.5 Metacognitive Processes

Kourilsky and Wittrock (1992), in a very powerful study, investigated the effect of teaching the overall generative model of teaching, including its four processes and activities, to senior high school students. The seniors were taught economics in cooperative learning groups. Those students who were taught this way of thinking were found to be more confident, had significantly fewer misconceptions, and had greater comprehension than those without this training. A fascinating result consistent with the Hooper, Sales, and Rysavy (1994) study was that just using cooperative learning groups alone did not produce as great an effect.

Kourilsky (1993) taught professional teachers generative teaching strategies and economic misconceptions. She found that pre- to posttest gain on exams of comprehension and misunderstanding were significant when misconceptions were clarified.

31.2.6 Summary

As can be seen, a variety of studies reporting on results of generative strategies have been summarized here. This section is not intended to be exhaustive; rather the studies have been selected as representative of the kind of research that has been conducted across content areas, learning types, and age levels. However, all articles that could be found that specify generative learning as the theory being tested are included. In general, results have shown increased gains in learning when the learner is an active vs. a passive participant in the learning process and when instruction includes activities that relate new information together and new information to prior knowledge. These studies on generative learning have shown that in most cases, active learner involvement produced increased learning—i.e., learner-generated activities have resulted in significant gains in learning, although issues of organization of lesson content and quality of response may affect the degree of the effect.

31.3 FOR THE PRESENT: THE GENERATIVE MODEL OF TEACHING AND IMPLICATIONS FOR THE DESIGN OF INSTRUCTION

The goal of instructional message design which follows generative learning theory is to create effective instruction that is organized and causes some level of mental activity on the part of the learner. "Effective instruction [in the generative model of learning] causes the learner to generate a relationship between new information and previous experience" (Wittrock, 1974a, p. 182). As a generative model of teaching, generative learning theory offers many practical guidelines and suggestions that extend beyond simply suggesting those learning activities that induce relationship building. From the description of the components of generative-learning theory presented earlier in this chapter, one must recall that generative-learning theory has four processes that work in tandem to create learning: motivation, learning, knowledge creation, and generation. Ignoring any one of these processes could result in the learner's taking a "passive," mentally disengaged approach to learning.

The generative model of teaching (Wittrock, 1991) takes into consideration these four components. Creating a teaching model to provide practical prescriptions for teachers was his original intent in pursing this area of research. As such, he provides some important teaching recommendations that affect the four processes of his model.

31.3.1 Motivation Processes

Wittrock (1991) specifies interest and attribution as the two essential and linked components of motivation processes (see Figs. 31-1 and 31-2) that are activated by arousal and intention through the descending reticular activation system. Research from other areas suggests that attribution of effort, or the process of giving credit for success or failure to one's own effort, can influence whether or not the learner will exert the effort to learn actively. If the learners attribute success to themselves, it follows that motivation to exert effort will be greater than if they attribute success to external forces (Weiner, 1979). The influence of intention on motivation for meaning generation flows from within the learner. Wittrock (1990, 1991) suggests that addressing this component means providing opportunities for the learner to "take control and responsibility for being active in learning" (p. 175). Teaching and design strategies that deal with attribution should result in enduring interest, persistence, and motivation. He suggests those activities or teaching strategies that:

- Attribute learning to their own effort
- Improve self-concept
- Create satisfaction from the process of learning
- Modify their perception of themselves as learners
- Create control and increase responsibility and accountability for learning
- Use rewards and praise that can be directly attributable to their effort

31.3.2 Learning Processes

Arousal and intention in the brain also influence an individual's learning processes. External stimuli arouse attention through the ascending reticular activating system. Without active, dynamic, and selective attending of environmental stimuli, it follows that meaning generation cannot occur regarding that environmental stimuli. The influence of arousal on attention flows from the environment outside of the learner, but interacts internally. The learning process that is key to this model is attention. Without attention, learning cannot occur. Teaching and design activities that can assist in gaining and maintaining attention include those that:

- Provide attention training by self-control, planning, and organizing
- Provide behavioral objectives and adjunct questions
- Provide interpretation of the importance of topic selected
- Use problems, mysteries, inconsistencies, suspense, and enigmas
- Direct students' voluntary attention to meaning

31.3.3 Knowledge Creation Processes

Knowledge creation processes are those components of memory—including preconceptions, beliefs, concepts, metacognitions, and experiences—activated through the frontal lobes of the cortex, which manage the receipt, coding, and storage of information. It is between these existing beliefs, concepts, preconceptions, etc., and environmental stimuli that relationships are formed, and, thereby, understanding and comprehension are generated (Wittrock, 1990, 1991). Much of his writing and research with colleagues addresses the notion of preconceptions as they influence learning misconceptions (Kourilsky & Wittrock, 1987). Some would assert that creating dissonance in the learner is one way to "unteach" misconceptions. Wittrock (1990) would argue that those dissonant situations must be carefully selected experiences that are real to the learners so that the situation cannot be easily dismissed by the learner as untrue. He also suggests teaching scientific conceptions early—before preconceptions are formed.

Preconceptions about learning and the learning process also function as a primary influence on learning. It may be necessary to change one's beliefs about learning and the learner's role in order to understand the value of participating in generative activities.

Other strategy recommendations offered by Wittrock (1990, 1991) include:

- Relating instruction to background knowledge and interest
- Teaching metacognitive processes to monitor learning actively
- Demonstrating tangible results from active learning

31.3.4 Generation Processes

"The art of generative teaching is knowing how and when to facilitate the learner's construction of relations among the parts of the text and their knowledge" (Wittrock, 1990, p. 353). Stimulated by the frontal lobes of the cortex, learners generate relationships between parts of what they see and hear. By integrating that information with what exists in memory, learners reorganize, elaborate, and/or reconceptualize information.

There are two types of activities that can be judged as generative. Those that generate organizational relationships between different components of the environment include "titles, headings, questions, objectives, summaries, graphs, tables, and main ideas." Those that generate integrated relationships between the external stimuli and the memory components include "demonstrations, metaphors, analogies, examples, pictures, applications, interpretations, paraphrases, inferences" (Wittrock, p. 354).

Both of these types of activities can be used in an instructor-provided or learner-generated format. In other words, the teacher can create titles and headings as organizers, or ask the learner to create a title or heading. When the instructor provides the actual relationship, it should be done in a manner that would direct attention. One way to do that is to relate those connections to ideas that are highly relevant to the learner. They should capture attention *and* motivate learners to think actively about the information. Wittrock advises that even though the instructor makes connections for the learners, learners must make those connections actively themselves in order for them to be learned. Passive observation will not suffice.

Given that there are many types of relationship-building activities that can be selected, a guide for selecting from among those activities is appropriate. Although Wittrock claims that levels of thinking are not represented in his theory and only designates two types of relationship building, it is evident that, by examining the level of mental effort required for each of these activities, the two categories can be broken down even further. Those activities that relate parts of the information in the environment together include coding, organization, and conceptualization levels of thinking, while those that relate parts of the information to prior knowledge include integration and translation tasks. Those activities that relate to the various levels are shown in Table 31-3 (Grabowski, 1995).

31.3.5 Summary

The recommendations that follow from Wittrock's writings provide straightforward ideas to be implemented by teachers and designers for any instructional medium, and should not be ignored. Whether we are designing for the computer, print, television, or instructor-led training, these principles hold. Engaging the learner in active processing of the information should be our primary goal.

The computer can be exploited as a powerful means to engage learners by tapping its capability as a mental construction tool, rather than in the traditional page-turner sense. Following Wittrock's principles, one should put the control of learning in the hands of the learner by creating an advisory environment in which learners manipulate information by moving text, graphics, and media segments around mentally or physically, testing their own ideas. This does not mean placing the learner in a total learner-controlled *information* environment, but rather in one in which success can be guided, rewarded, and reinforced.

Creating a transactive environment (between the learner and the materials) is more of a challenge when designing for more static media, but it can be done cleverly by giving conscious attention to the design of the message to induce thinking—such as "stop and think activities" (Arnone & Grabowski, 1992), incomplete messages, and rhetorical adjunct questions to direct and engage thought.

The second important message from Wittrock is that more time and effort be spent on identifying important

TABLE 31-3. MATCH OF GENERATIVE ACTIVITY WITH LEVEL OF PROCESSING

Level of Cognitive Processing	Recommended Generative Activities
Coding	creating titles and headings
Organization	outlining summarizing diagramming
Conceptualization	paraphrasing explaining/clarifying creating concept maps identifying important information
Integration	creating relevant examples relating to prior knowledge creating analogies creating metaphors synthesizing
Translation	evaluating questioning analyzing predicting inferring

factors about the learner than is traditionally spent in the instructional design process. Identifying the learner has always been an important step in the instructional design process; however, how to do this, or the kind of key information to gather, is rarely specified. Wittrock's writings show some clear elements: Gather conceptual preconceptions, preconceptions about their learning the topic, preconceptions about their role as learners, prior knowledge relating to the topic, general prior knowledge, and metacognitive abilities. This knowledge, combined with a good understanding of appropriate activities that draw relationships, should result in very effective instruction.

31.4 THE FUTURE

31.4.1 Implications for Research

The potential for continuing and extending research on the effects of generative activities is considerable. What is currently evident from past research is the validity of Wittrock's basic premise of active learner engagement. Further research is necessary to help in selecting the type and mode of activity. In other words, we need to ask when various generative activities are more appropriate than others, and whether they should be used in an instructor-provided format or learner-generated one. Given past research results and these capabilities, these two broad agendas can be specified.

31.4.1.1. Selection of the Type of Generative Activity. In the previous section, a table of activities was proposed which matches generative activities to desired levels of cognitive processing. This matching must be empirically tested. Questions such as the following take this into account:

1. What are the effects of each generative activity on higher-level learning? Much of the previous research has emphasized fact and concept-level learning and has not dealt with higher-level learning such as application, synthesis, or problem solving.
2. Are there clusters of generative activities that are best used for specific learning tasks or levels of learning? Are, for example, analogies appropriate for fact-level learning?

31.4.1.2. Use of Generative Activities. Previous research has also indicated mixed results from activities requiring overt/covert responses. Because of a "veto power over learning," described by Rothkopf (1976, p. 94), further research should explore the conditions that may require overt manifestations to ensure that processing occurs.

3. Is there a differential effect from requiring or not requiring overt manifestations of generative activity? What are the best strategies (instructional and mechanical) for controlling that information is manipulated in the mind?

31.4.1.3. Motivation, Learner, and Knowledge Creation Processes. Another very significant area of research is identifying strategies that will enhance the perception of learner responsibility. This indicates a need to merge the learner control research with that of generative learning. From Wittrock's writing, it seems apparent that learner control with advisement would be recommended, but it needs to be empirically tested with questions such as:

4. What are the best methods for providing advisory feedback on learner-generated conceptions of the instruction content, and what are their effects?
5. What is the effect on learning of directive, embedded, or inductive control when motivation level varies? Several strategies have been proposed by various researchers. Directive control, as defined by Rothkopf (1976), takes the form of directions that are given to a learner to perform a particular task. Embedded strategies are similar to Rothkopf's inductive control in that they may not be obvious to the learner. Inductive control does not force a response, however, while an embedded strategy expects the learner to perform the behavior before going on (Rigney, 1980).

31.4.1.4. Instructor Provided or Learner Generated? Some of the research results reported earlier indicate that both developmental and cognitive strengths may play a part in selecting appropriate and successful activities. Besides learner-generated activities in which the learner actively makes connections, Bovy (1981) suggests that instructor-provided activities supplant cognitive connections that are provided for the learner by the instruction itself (instructor generated, not learner generated, but personally relevant). There is also another category of instruction in which no control is provided: offering no suggestions, no forced responses, and no supplanted cognitive strategies. The following table proposes a matching of cognitive strengths with levels of thinking and recommended generative activities. If the activity is one that matches the cognitive strengths of individuals, then perhaps it should be presented in a learner-generated format. If it is an activity that would frustrate the learner—i.e., it is not a cognitive strength—then it should be presented in an instructor-provided format, so that the mental effort can be concentrated on the meaning of the message, rather than on a frustrated attempt at using a technique that does not match one's cognitive style. Providing no guidance may well be saved for learners with well-developed metacognitive abilities (see Table 31-4).

Research designs should then test the effect of these three presentational strategies (learner generated, supplanted, or no control) for each generative-learning strategy matched by cognitive style or other individual difference factors against desired levels of learning or the cognitive processing requirements of the specific task. Cognitive developmental issues should also be considered. The following research questions should yield very important prescriptions:

6. Is there an appropriate use for supplanted vs. generated learning? Does this vary by task or learner?
7. Which activities match with developmental levels of learners?

TABLE 31-4. THEORETICAL MATCH OF GENERATIVE ACTIVITY WITH COGNITIVE STRENGTHS

Cognitive Style Type	Cognitive Strength	Learner-Generated Activity	Instructor-Provided Activity
Breadth of Categorization—Organizational Thinking			
	broad	create summaries create main ideas	provide outlines
	narrow	outline	provide summaries provide main ideas
Organizational Patterns—Organizational Thinking			
	global	create summaries create diagrams	provide outline
	analytic	create outline	provide summaries provide diagrams
Variation in Memory—Organizational Thinking			
	leveling	create summaries	provide outlines
	sharpening	create outlines	provide summaries
Conceptual Styles—Conceptualization			
	relational	create concept maps	explain/clarify identify important information provide paraphrases
	analytic/ descriptive	explain/clarify identify important information	provide concept maps provide paraphrases
	categorical/ inferential	paraphrase	provide concept maps explain/clarify identify important information
Cognitive Dimension—Integration			
	complexity (abstract)	create analogies create metaphors	provide relevant examples relate to prior knowledge
	simplicity (concrete)	create relevant examples relate to prior knowledge	provide analogies provide metaphors
Thinking Patterns—Organization, Conceptualization, Integration, Translation			
	Convergent		
Organizational		creating outlines creating diagrams	provide summaries
Conceptualization		explaining/clarifying identifying important information	provide concept maps paraphrase
Integration		relate to prior knowledge create relevant examples	provide analogies provide metaphor
Translation		evaluation analysis inference	question provide predictions
	Divergent		
Organizational		create summaries	provide outlines provide diagrams
Conceptualization		create concept maps paraphrase	explain/clarify identify important information
Integration		create analogies create metaphors	relate to prior knowledge provide relevant examples
Translation		question make predictions	evaluation analysis inference

31.5 CONCLUSION

The principles behind generative learning offer the instructional designer much guidance for developing effective instruction that emphasizes the learner as an active partner in the instructional process. There is much research that has been done to support this position, and there is much research to do to figure out how to help the designer to create a learning environment that promotes this active mental processing at all stages and levels of learning. All of the evidence indicates, in my view, that it is an area of very fruitful work that should continue.

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