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Generative Learning: Principles and Implications for Making Meaning

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ABSTRACT

The first and second edition of this chapter defined generative learning and its foundations and presented relevant research that tested the theory. The primary goal of this edition is to reconceptualize the processes for making meaning by synthesizing theoretical foundations of generative learning and exploring generative

learning effects by different types of learning outcomes. The essence of this model of generative learning is knowledge generation. Only through learners' generation of relationships and meaning themselves can knowledge be generated that is sustainable—this is the essential process of meaning making by the learner. Likewise, only those activities that involve the actual creation of relationships and meaning would be

classified as examples of generative learning strategies. A variety of studies reporting on results of generative strategies have shown that, in most cases, active learner involvement produced increased gains in recall, comprehension, and higher order thinking or improvement in self-regulated learning skill. Misconception, providing feedback, and developmental appropriateness are issues that have emerged as unresolved. As such, there is much research left to do to establish specific guidelines that help the designer create a learning environment that stimulates attention and intention, promotes active mental processing at all stages and levels of learning, and provides the learner with appropriate help in the generation process.

KEYWORDS

Attention: Arousal and intention in the brain that influence an individual's learning processes. Without active, dynamic, and selective attending of environmental stimuli, it follows that meaning generation cannot occur.

Knowledge generation: Generation of understanding through developing relationships between and among ideas.

Meaning making: The process of connecting new information with prior knowledge, affected by one's intention, motivation, and strategies employed.

Motivation processes: Wittrock (1991) specified interest and attribution as being the two essential and linked components of motivation processes activated by arousal and intention through the descending reticular activation system.

Self-regulation: Active participation in terms of behavior, motivation, and metacognition in one's own learning process (Zimmerman, 1986).

INTRODUCTION

The internal processes of learning and how they are stimulated are of prime importance to instructional designers. These processes are understood through extensive theoretical conceptions and predictions and empirical evidence about cognitive functioning, processes, and the structure of memory. Using theoretical foundations about learning, designers develop a conception of the thinking that occurs within the learner, and they use this conception to guide the design of learning environments. One important concept explaining these processes is generative learning theory. Generative learning theory, with its companion model, generative teaching, has a foundation in neural research as

well as research regarding the structure of knowledge and cognitive development. Generative learning theory focuses on selecting appropriate, learner-centric instructional activities for the learner. This theory is one that combines the importance of learner and instructional intentionality. Because of this blending, Bonn and Grabowski (2001) call generative learning theory a practical cousin of constructivism. Perhaps it also provides a more complete perspective about learning, making it a second cousin to behaviorism. The theory brings together our understanding of learning processes and the design of external stimuli or instruction. Describing how meaning is made for different types of learning outcomes is the challenge of this chapter.

MAKING MEANING IN GENERATIVE LEARNING

Generative Learning Foundations

Wittrock (1974a,b) was the founder of generative learning theory. His beliefs about learning were influenced by research in several areas of cognitive psychology, including cognitive development, human learning, human abilities, information processing, and aptitude treatment interactions. His work explains and prescribes teaching strategies to maximize reading comprehension. In his theory, Wittrock emphasized one very significant and basic assumption: The learner is not a passive recipient of information; rather, he or she is an active participant in the learning process, working to construct meaningful understanding of information found in the environment. Wittrock (1974a, p. 182) stated 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." It is, as Harlen and Osborne (1985, p. 137) call it, "learning through the person."

Designing instruction based on this basic assumption, however, is not as simple or straightforward as it may first appear. Wittrock built his model around four parts based on a neural model of brain functioning (Luria, 1973) and cognitive research on the process of knowing (Wittrock, 1992). As is evident from the empirical results that are reported later in this chapter, those studies that apply a simplistic rather than a holistic perspective result in mixed or unpredicted findings. It is important, therefore, to elaborate on the interrelationship of the four parts to Wittrock's model: generation, motivation, learning, and knowledge creation. Metacognitive processes also play a key role in this model, although in most cases Wittrock folds metacognition into the knowledge creation process.

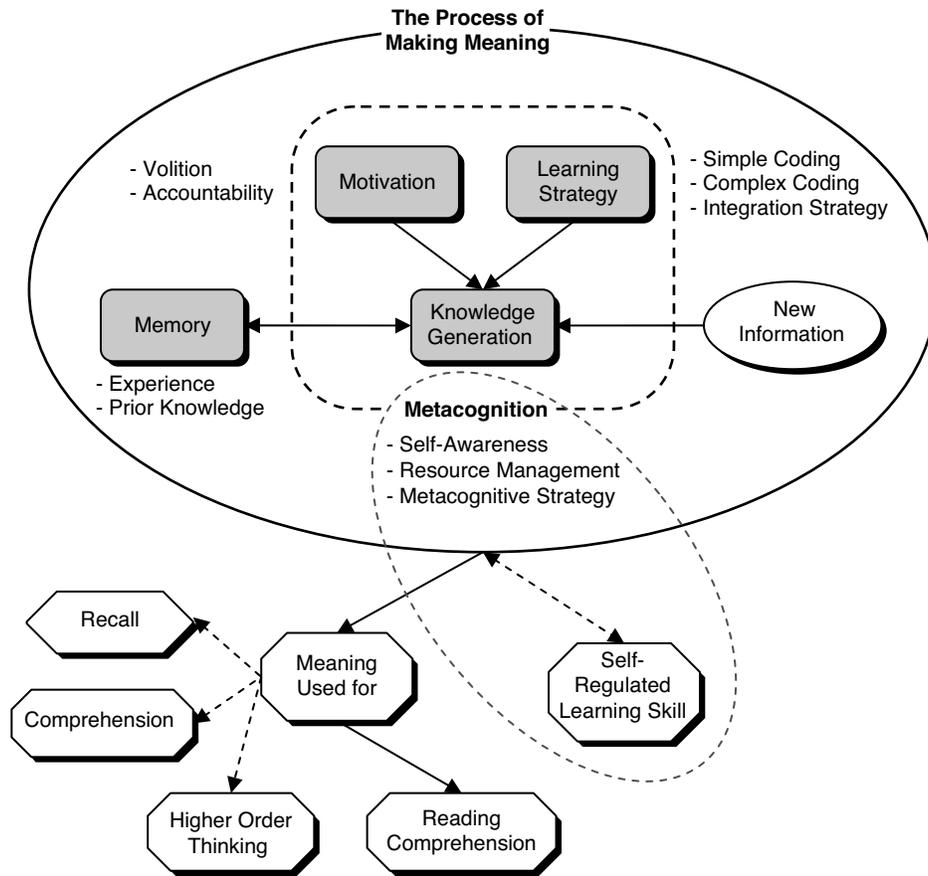


Figure 10.1 Conceptual understanding of generative learning.

Interrelationship of the Components of Generative Learning

The concept map in Figure 10.1 is illustrative of our conceptualization of the ideas presented in Wittrock’s writings (1974a,b, 1985, 1990, 1991, 1992) and in Grabowski’s (2004) concept map regarding the progression of generative learning. As shown inside the dotted rectangle in Figure 10.1, the essence of generative learning is knowledge generation. Only through the *learner’s self-generation* of relationships and understanding can knowledge be generated meaningfully. Only those activities that involve the actual creation of relationships and meaning would be classified as examples of generative learning strategies. Restructuring of environmental information by definition requires the learner to generate either organizational or integrated relationships and construct personal meaning. One part of meaning making results from the processes of generating relations between memory including preconceptions, abstract knowledge, everyday experience, domain-specific knowledge, and new

information (Wittrock, 1974b). This connection is shown by the connecting arrows. Generation can result in schema fitting (Rummelhart, 1981; Rummelhart and Ortony, 1977).

Basically, data points or schemata 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 it is easily retrievable. This connection is made by adding information to schema, restructuring, or tuning it. Although 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 remind learners of prior knowledge and relate the information to what the learners already know. It is less relevant who selects those connection points compared to the fact that they are made.

By definition, learners should become accountable and responsible in learning and mentally active

in constructing relations between what they know and what they are learning (Wittrock, 1990). Motivation, the second of Wittrock's components shown inside the dotted rectangle, promotes the impulse or intention to learn or carry out a task (Corno, 2001). Persistence and sustained interest in knowledge generation process is one essential component of the motivation process of this model. Interest can be enhanced only when the learners attribute successful comprehension to their own effort at knowledge generation (Wittrock, 1991).

Learners who are motivated to generate meaning between their memory and new information need to use various learning strategies from simple coding to integration strategies. Depending on their motivation level or memory, such as prior learning on domain or learning strategy, or learners' preference, learners employ different learning strategies in knowledge generation. This process can be explained by information-processing theory: the process of thinking and memory storage—in other words, the stages and levels of processing. What we take from 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 transferring information.

Finally, Wittrock (1991) emphasized that learners should control their own generative processes. Metacognition regulates one's cognitive activities in learning processes and therefore surrounds the three generative learning processes shown in Figure 10.1 (Brown, 1978; Flavell, 1979). Self-monitoring is a vital process here because it informs learners about their progress (Zimmerman, 1998). Based on self-monitoring, learners manage their effort and available resources and change their learning strategies to generate meaning.

In summary, to make meaning, learners actually create relationships among or between their memory and new information. Learners are mentally active and use various learning strategies in this knowledge generation process. Also, learners metacognitively self-regulate this process. The outcome of this knowledge generation was originally investigated in reading comprehension, and many researchers extended this model to investigate a variety of generative learning strategies that were expected to promote different levels of learning in a variety of domains. Recently, researchers have explored higher order thinking and self-regulated learning skills as outcomes of generative learning.

APPLIED RESEARCH

Synthesis from the Learning Process Perspective

Learning strategies, as illustrated in Figure 10.1, that are employed to generate knowledge and meaning during the learning process are the most frequently studied component of generative learning theory. For example, many research studies have tested the effects of simple coding strategies such as underlining, note taking, and adjunct or inserted questions; more complex coding organizational strategies, such as the creation of hierarchies, headings, summaries, and concept maps or manipulation of objects; and, finally, elaborative integration strategies such as imaging and creation of examples, interpretations, or analogies (Table 10.1).

An analysis was conducted from this strategy perspective in the first two editions of this chapter. From this perspective, three conclusions could be drawn. First, when comparing generative strategies treatment and control groups, researchers often found no significant differences, indicating that mental activity cannot be strictly controlled by instruction, and this finding raised the issue that requiring an overt response may be more effective in encouraging the desired result (Anderson and Kulhavy, 1972; Peper and Mayer, 1986; Shrager and Mayer, 1989).

Second, investigation of the subject-generated vs. experimenter-provided activity is a relatively common theme in generative learning studies (see, for example, Barnett et al., 1981; Bull and Wittrock, 1973; Doctorow et al., 1978; Rickards and August, 1975; Smith and Dwyer, 1995; Stein and Bransford, 1979). These research results are mixed with learning gains not consistently predicted by this factor.

Third, comparing the various types of generative strategies is another major research theme (Hooper et al., 1994; McKeague and DiVesta, 1996; Wittrock and Alesandrini, 1990). Again, looking at generative learning from this perspective did not result in consistent or definitive guidelines for its use. Although some of the research has found some generative learning strategies to be effective, the results are mixed when examining them by learning strategy type, and they warrant a different type of analysis.

Synthesis from a Learning Outcomes Perspective

Four categories of criterion measures emerged when examining research on generative learning strategies from a learning outcomes perspective: recall, comprehension, higher order thinking, and self-regulation skill.

Recall

According to the research summarized in Table 10.1, recall is the most frequently studied criterion measure. Wittrock and Carter (1975) conducted a study examining free recall in generative vs. reproductive treatments. The generative group was directed to organize the hierarchies, whereas 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 on free recall than the unrelated generative group. Burton et al. (1986) investigated the effect of superordinate and subordinate questions by using a secondary task probe technique and a passage about a mythical country. The overall results indicated that more main ideas were recalled than details.

Davis and Hult (1997) studied immediate and delayed free recall in note taking and writing summaries in introductory psychology classes. Their results support the findings of Barnett et al. (1981) that writing summaries during pauses in the lecture note-taking activity significantly improved free recall and delayed retention. King (1992) examined the effect of self-questioning, summarizing, and note taking on immediate and delayed recall of under-prepared college students. On immediate recall, summarizers performed better than self-questioners, who were better than note takers, indicating a progressive generative effect. Self-questioners performed best on the delayed tests, indicating that deeper processing may occur in more generative tasks such as self-questioning. Woods and Bernard (1987) also found effects of adjunct conceptual post-questions on encouraging a greater depth of processing of verbal information among adults 60 years of age 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. Shrager and Mayer (1989) reported interesting results regarding aptitude–treatment interaction research. Note takers recalled more than non-note takers for students with low levels of prior knowledge but not for those with high levels of prior knowledge.

To summarize these findings, recall has been often used as dependent variable in the studies for simple coding strategies. In addition, some researchers reported that the higher the level of generativity, the higher the score on delayed recall. Research findings, however, are mixed with regard to the type of strategies, measurement instrument, and the interaction with individual differences.

Comprehension

In two experiments with elementary-school children, Doctorow et al. (1978) studied the effect of learner-generated vs. experimenter-provided paragraph headings and sentence meanings on comprehension. The combination of text organized through the use of headings plus learner-generated sentences about the paragraphs produced dramatic gains in reading comprehension. 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. Two studies tested the effect of a combination of generative strategies on comprehension. The treatments of Carnine and Kinder (1985) study were images, corrective feedback, and summary to study reading comprehension. They found significant gains from pre- to post-tests for both narrative and expository text. Linden and Wittrock (1981) also tested the effect of images, summary sentences, and analogies, all of which increased and correlated with comprehension.

Several studies have tested the effect of concept mapping on comprehension. Smith and Dwyer (1995) found a significant difference only on lower level terminology tasks, not on a comprehension task, in favor of instructor-provided maps. Similarly, two other studies (Kenny, 1995; Taricani, 2002) found no effects of learner-generated graphic organizers or concept maps on comprehension. In the Taricani (2002) study, feedback was also tested against generativity to evaluate the notion that learner generation can create misconceptions that are corrected before testing; however, the blending of concept mapping and feedback did not assist in overall learning of terminology and comprehension. Wang (2003) also tested the effect of different types of concept mapping strategies on terminology and comprehension. Students who were given partially predeveloped concept maps performed better on all levels of learning outcome, but students who created their own concept map groups performed better only on terminology.

In summary, the effect of complex coding strategies on comprehension is still mixed, but simple coding strategies are consistently reported to be effective for aiding comprehension. Higher levels of generativity when using complex coding strategies (e.g., learner-generated concept map) did not seem to be effective for improving comprehension.

Higher Order Thinking

Research has also investigated problem solving, reasoning, inference, and application. Among the research, problem solving has been tested by a few

TABLE 10.1
Summary of Selected Applied Generative Research Studies

Learning Outcome	Generative Activity	Author/Year	Content	Age Level	Results
Recall	<i>Note taking</i>				
	Note taking, elaborated and simple review; instructor-provided and learner-generated notes	Barnett et al. (1981)	History	Undergraduates	Note taking produced better results than no note taking, but there was 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 were higher for questions from learner notes.
	Writing summaries during note taking	Davis and Hult (1997)	Introductory psychology	Undergraduates	Summary group scored significantly higher on free recall and delayed retention test.
	<i>Adjunct questions</i>				
	Adjunct questions: super-subordinate post-questions	Burton et al. (1986)	Description of a mythical country	Undergraduates	More main ideas were recalled, and general questions were more engaging than detailed ones.
	Adjunct post-questions	Woods and Bernard (1987)	Weather forecasting	Adults ages 60 years or older	Adjunct questions aided recall of intentional ideas only.
	<i>Organizational strategies</i>				
	Organization hierarchies	Witrock and Carter (1975)	Mineral tables	Undergraduates	Learner-generated hierarchies for disorganized lists were significantly better than simply reproducing them. Reproducing organized hierarchies was significantly better than learner-generated ones.
	<i>Manipulation of objects</i>				
	Individual and group concept mapping and object manipulation; sequence of activities	Ritchie and Volkl (2000)	Science	Sixth-grade children	No difference was found between concept mapping and manipulatives on immediate recall and those who worked in teams vs. those who worked individually. Performance was significantly better for those who created concept maps first and then used the manipulatives on the delayed posttest. Interaction was found between strategy and individual/team on immediate and delayed recall; those who created concept maps in teams performed significantly better than those who used the manipulatives in teams. The opposite effect was found for intermediate recall.
<i>Imaging</i>					
Imaging: experimenter provided and learner generated	Bull and Witrock (1973)	Definitions of nouns	Elementary-school students	Recall was significantly higher for imaging than the verbal/copying strategy.	

<i>Elaborations</i>						
Elaboration interpretation	Johnsey et al. (1992)	Professional development	Adults	Results favored the use of embedded vs. detached elaboration strategies. Elaborations were better than no elaborations. No difference was found between learner-generated and experimenter-provided.		
<i>Combination of coding and integration</i>						
Self-questioning, summarizing, and note taking	King (1992)	Generic lecture	Underprepared undergraduates	Immediate: Summarizers performed better than self-questioners, who performed better than note takers. Delayed: Self-questioners performed better than summarizers, who performed better than note takers.		
<i>Underlining</i>						
Underlining	Richards and August (1975)	Educational psychology	Undergraduates	Achievement increased on post-test when learner underlined most relevant information.		
<i>Note taking</i>						
Précising vs. rereading, underlining, or signaling	McGuire (1999)	Reading	ESL learners	Précising resulted in higher comprehension over rereading, underlining, or signaling		
<i>Adjunct questions</i>						
Adjunct pictures	Brody and Legenza (1980)	History	Undergraduates	Post-pictures were more beneficial than pre-pictures		
<i>Organizational strategies</i>						
Organization headings, sentence meaning	Doctorow et al. (1978)	SRA literature	Elementary-school students	Learner-generated sentences combined with experimenter-provided headings produced increased comprehension, followed by generative only.		
Physical manipulation of objects	Sayeki et al. (1991)	Math	Elementary-school students	Post-test showed physical manipulation facilitated graphics increased problem solving over static or computer-manipulated graphics.		
Graphic organizers	Kenny (1995)	Nursing elderly patients	University nursing students and faculty	Significantly poorer performance on the immediate learning and retention tests for those generative graphic organizers than those given a graphic organizer.		
<i>Imaging</i>						
Verbal and image elaborations: sequence	Kourilsky and Wittrock (1987)	Economics	High-school students	Verbal-to-image elaborations were significantly better than image to verbal or either used singularly.		
<i>Elaborations</i>						
Elaborations elaborated sentences	Stein and Bransford (1979)	Language arts	Undergraduates	Performance was facilitated only when elaborations clarified precise objectives; prompting encouraged subjects to ask more relevant questions.		
Elaboration examples	DiVesta and Peverley (1984)	Fictitious concept	Undergraduates	Students who generated their own examples did significantly better on far-transfer tasks than those given instructor-provided examples.		

**TABLE 10.1 (cont.)
Summary of Selected Applied Generative Research Studies**

Learning Outcome	Generative Activity	Author/Year	Content	Age Level	Results
	<i>Combination of coding and integration</i>				
	Images, verbalization of the image and summaries, structural adjunct questions	Carmine and Kinder (1985)	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, analogies and question answering in different sequences	Boulaoude and Tamin (1998)	Science	Seventh-grade students	No differences were found for strategy or sequence. Students preferred summaries the most; questions, because they were easy; analogies, for fun; and summaries, for their helpfulness.
	<i>Metacognitive strategy</i>				
	Generative learning processes training	Kourilsky and Wittrock (1992)	Economics	High-school seniors	Generative learning procedures significantly increased confidence and decreased level of misunderstanding.
	Generative learning training	Kourilsky (1993)	Economics	Professional teachers	Pre- to post-test gains on both exams were significant when misconceptions were clarified and learning was covered again.
Recall and comprehension	<i>Note taking</i>				
	Note taking	Peper and Mayer (1986)	Auto engines	High-school and college students	Note taking increased achievement for far-transfer problem solving but not near-transfer fact retention.
	Note taking	Shrager and Mayer (1989)	How to use a camera	Undergraduates	Confirmed above findings; also, significant differences were found for students with low prior knowledge.
	<i>Organizational strategies</i>				
	Concept maps	Smith and Dwyer (1995)	Human heart	Undergraduates	Learners using instructor-provided concept maps performed better on identification tests only; no other differences were found.
	Concept maps: partial and total learner generated by feedback	Taricani (2002)	Human heart	Undergraduates	Providing feedback resulted in higher terminology scores on partially generated map
	Concept maps: concept matching mapping, proposition identifying mapping, and student-generated concept mapping	Wang (2003)	Heart content	Undergraduates	Concept matching mapping strategy was the most effective among the three strategies.
<i>Imaging</i>	Imaging	Anderson and Kulhavy (1972)	Fictitious description of a tribe of people	High-school seniors	Significant differences were found in favor of those who actually used an imaging strategy.

	<i>Combination of coding and integration</i>					
	Summaries, and analogies	Wittrock and Alesandrini (1990)	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 and Wittrock (1981)	Reading	Elementary-school students		All generations were increased and correlated with comprehension. More generations were produced when images were produced before verbal elaborations. No difference was found for generation sequence. Results were mixed for factual recall. No effect by strategy was found. Students performed better in the guided activities than the active learner groups.
	Strategy orientation (underlining, headings, and analogies) by guided vs. active activity	McKeague and DiVesta (1996)	Radar	Undergraduates		
Higher order thinking skill	<i>Adjunct questions</i> Adjunct questions: frequency, nature of, need for feedback, overt/covert response	Anderson and Biddle (1975)	Across content areas	Across age levels		Learning was better with more frequent questions. No difference was found when feedback was given. Overt response was needed depending on if questions were embedded. No significant differences were found between groups
	Adjunct postquestions with no overt responses	Sutliff (1986)	Electrical engineering	Low-and upper-ability college students		
	<i>Organizational strategies</i> Linear, navigational, and generative computer text	Barab et al. (1999)	Social studies	Undergraduates		Navigational and generative group performed better in problem solving. Linear group performed better in reading comprehension. Generative map outperformed completed map in well-structured problem solving.
	Generated map vs. completed map	Lee and Nelson (2005)	Designing instruction	Undergraduates		
	<i>Imaging</i> Verbal only, image only, and combined elaborations	Laney (1990)	Economics	Third-grade children		Verbal-only and verbal-to-image integrated strategies facilitated reasoning better than imagery only.
	<i>Metacognitive strategy</i> Instruction on summary writing versus reflection training	Friend (2001)	Reading comprehension	Unskilled undergraduate writers		Instruction on how to write effective summaries was more effective.
Comprehension and higher-order thinking skill	<i>Organizational strategies</i> Concept vs. semantic maps	Beissner et al. (1993)	Human heart	Undergraduates		Learner-generated concept maps were the better strategy for holists. Learner-generated semantic maps were better for serialists for problem-solving learning only.

**TABLE 10.1 (cont.)
Summary of Selected Applied Generative Research Studies**

Learning Outcome	Generative Activity	Author/Year	Content	Age Level	Results
Recall, comprehension, and higher order thinking skills	<i>Manipulation of objects</i> Mouse-manipulated graphics	Haag and Grabowski (1994)	Human heart	Undergraduate	Learner-manipulated graphics increased problem solving over static or computer-manipulated graphics.
Higher-order thinking skill and SRL	Organizational strategies Concept mapping	Chularut and DeBacker (2004)	ESL	College students	Concept mapping group scored higher in achievement and self-monitoring. High proficiency group scored higher in achievement, self-monitoring, and self-efficacy. The difference in gains over time in achievement, self-monitoring, and self-efficacy between the concept mapping group and control group were greater for the higher English proficiency group.

studies. In research comparing note takers and non-note takers who were learning how to use a camera, Shrager and Mayer (1989) concluded that note takers with low prior knowledge solved transfer problems better than non-note takers with low prior knowledge. Barab et al. (1999) also reported that students in the generative activity group performed better in problem solving in a computer-based learning environment. Regarding organizational strategy, Beissner et al. (1993) compared the effects of learner-generated concept maps and serial maps with learner differences at four levels of learning. Their findings showed an interaction between concept vs. semantic maps and serialist or holist learners on the problem-solving questions only, with serialists performing better with semantic maps and holists performing better with concept maps. In a more recent study, Lee and Nelson (2005) compared the effect of learner-generated concept maps and instructor-generated concept maps on problem solving. Research results showed that the learner-generated concept map group outperformed the instructor-generated map group in well-structured problem solving. They also reported an interaction effect with learners' prior knowledge: The high prior knowledge group benefited more from the activity of concept map generation than the low prior knowledge group.

On the other hand, Laney (1990) and Sutliff (1986) examined the effect of generative strategies on reasoning and inference respectively. In Laney's study, the verbal-only strategy and the integration of verbal and imaging strategy were more effective than the imaging-only strategy on the economic reasoning of third-graders. He felt that his results were consistent with Wittrock's notion that the effective use of imaging is developmental. Laney's third-grade subjects had not yet developed this ability and were more familiar with verbal instruction. Sutliff investigated the effect of inserted questions on reducing passivity in a self-instructional slide-tape presentation as evidenced by increased learning of facts and inference. He reported that there were no significant differences between groups, which is in contrast to prior research reporting significantly different effects of questions.

In sum, most of the studies investigating higher order thinking skills dealt with complex coding strategies such as organization. Because it has been only a decade since we have begun investigating this topic with regard to generative learning, the research findings have not collectively supported each other; however, relatively more effort has been directed toward aptitude-treatment interaction research by considering learners' prior knowledge level or learning style.

Self-Regulation Skill

In recent years, there has been a resurgence of interest in self-regulated learning (SRL). This phenomenon can be explained from two perspectives. First, recent research findings support a positive relationship between students' self-regulating skill and their academic achievement (Azevedo and Cromley, 2004; Kramarski and Gutman, 2006; Pintrich and De Groot, 1990; Zimmerman, 1998; Zimmerman and Schunk, 2001). Second, a major goal of education is to train students to be skillful self-regulators to enable them to be life-long learners (Boekaerts, 1997; Boekaerts and Corno, 2005). "Self-regulated learners are behaviorally, motivationally, and metacognitively active participants in their own learning process" (Zimmerman, 1986). This interpretation is in line with Wittrock's emphasis on learners' motivation, cognitive learning strategy, and metacognitive process in the knowledge generation processes. In other words, self-regulation skills may play a vital role in generative learning, but learners can also develop their self-regulation skills through generative learning activities. Chularut and DeBacker (2004) investigated the effect of a generative learning strategy—concept mapping—on students' achievement and self-regulation and self-efficacy in learning English as a second language. They found that students who were using concept mapping had significantly greater achievement gains at post-test compared to pre-test. In addition to the benefit of achievement, their results showed that a positive effect of engaging in concept mapping increased students' self-regulation and self-efficacy relative to the control group.

Summary

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 some increased gains in recall, comprehension, and higher order thinking skill as well as improvement in self-regulated learning skill when the learner is an active partner 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 many cases, active learner involvement produced increased learning; that is, learner-generated activities have resulted in significant

gains in learning, although misconceptions, feedback, and developmental appropriateness require further investigation, and there remain some mixed findings based on generative learning strategies.

IMPLICATIONS FOR FURTHER RESEARCH

Past research verifies Wittrock's basic premise of active learner engagement; however, further research should explore the interrelationship of the four components as shown in Figure 10.1 (motivation, learning strategy, knowledge generation, metacognition) in making and applying meaning to predict higher recall, greater comprehension, better higher order thinking, and more controlled self-regulation. What appear to be weak or inconsistent results in previous research may be strengthened if all components are taken into account. Two such areas of research are proposed.

Motivation, Learner, and Knowledge Creation Processes

Identifying strategies that will enhance the perception of learner responsibility is one example of studying the interrelationships of the components. This indicates a need to merge the learner control research with that of generative learning to address such questions as:

- What are the best methods for providing advisory feedback on learner-generated conceptions of the instruction content, and what are their effects?
- What is the effect on learning of directive, embedded, or inductive control when motivation level varies?

Instructor-Provided or Learner-Generated and Self-Regulation?

In addition, a question remains as to the relationship between generative learning and learners' self-regulation. From Wittrock's definition, learners need to use their self-regulation skill during the knowledge generation process, and consequently the learners may increase not only their comprehension but also their self-regulation skill. Self-regulation seems to be of critical importance when learners are faced with generating their own understanding rather than having the instructor providing understanding, especially where misconceptions are possible. These relationships should be empirically tested by addressing such questions as:

- Is there any interaction between a learner's level of self-regulation skill and generative activities?
- What is the effect of generative learning strategies on a learner's self-regulated learning skill?

FINAL THOUGHTS

The principles behind generative learning offer the instructional designer much guidance for developing environments that engage the learner in active processing of the information in face-to-face, e-learning, or even informal learning environments. 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 around mentally or physically, testing their own understanding of the relationships they are building. This means putting learners in an environment in which success can be guided, rewarded, and reinforced. Generative learning theory is not discovery learning but student-centric learning with specified activities for actively constructing meaning. Generative learning activities require internal processing of external stimuli. A generative learning environment is not limited to open-ended resources, although it could engender those, and it includes carefully crafted external stimuli that are ready for individual processing. Generative activities are what exist between the external stimuli and the learner. Generative learning theory does not assume dominance of the role of the learner or instructor or instruction but rather a partnership in the process.

As a practical cousin to constructivism and a more complete second cousin to behaviorism, generative learning theory is easily applied to any learning or instructional setting. The subtle differences between this theory and other theories account for differences in instructor roles (the role of the sage). For behaviorism, the sage is on the stage. For constructivism, the sage is viewed as a guide. For generative learning theory, the *sage*, *guide*, and *learner* are in the center. Content, instructional expertise, and instructional intention are expected of the sage and guide. Active engagement, attention, and learning intention are also expected of the learner. Much research must yet be done to support this position, and there is much research left to do to establish specific guidelines that help the designer create a learning environment that stimulates attention and intention, promotes active mental processing at all stages and levels of learning, and provides appropriate

support in the generation process. The evidence indicates that generative learning theory is very applicable to instructional design and that research defining types of processing should continue.

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