Generative Learning Theory and its Application to Learning Resources

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Abstract

Generative Learning Theory (GLT) suggests that learning occurs when learners are both physically and cognitively active in organizing and integrating new information into their existing knowledge structures. The process of generating relationships among new and existing knowledge leads to meaning-making that leads to deeper understanding of content. Thus, incorporating GLT principles into learning resources should prompt learners to engage more deeply with instructional content. This paper provides an overview of GLT theoretical perspectives, research, and practices, summarizing points for the design of learning resources.

Introduction

Generative originates from the Latin word '*beget*' and is defined as 'having the power or function of generating, originating, producing, or reproducing' (Generative, n.d.). Hence, generative learning theory explains the brain processes that comprise the production of meaning or individual knowledge. Generative learning theorists define knowledge as the meaningful understanding of information through the creation of connections among new bits of information and between new information and memory. This paper revisits the history of development and research in generative learning theory to demonstrate its strength in explaining the processes of learning specific to the individual.

Merlin Wittrock first published generative learning theory in 1974 at a time when cognitivism was the popular philosophy of educators and the role of the individual in the learning environment was the focus of instruction. GLT is "student-centric learning with specified activities for actively constructing meaning" (Lee, Lim, Grabowski, 2008, p. 122). Thus, GLT suggests that learning occurs when learners are both actively and cognitively (mentally) organizing and integrating new information into their knowledge structures in meaningful ways. In GLT, learning is defined by learner-generated relationships.

GLT has been well tested in a variety of content areas, at multiple levels of learning, and across the learner age span (see Anderson & Biddle, 1975; Davis & Hult, 1997; Grabowski, 2004; Lee & Nelson, 2005; Wittrock & Carter, 1975). These studies provide empirical support that learners who engage with learning resources based on the tenets of GLT have higher average recall and retrieval than those who did not. This paper defines learning through the lens of GLT, outlines the four processes of the theory, highlights several GLT research studies and their findings, and provides guidelines for learning resources built on the foundation of GLT.

A Learning Scenario for Generative Learning Theory

The following learning scenario is provided as a model of generative learning to engage you in exploring GLT. For a few moments, place yourself in the role of learner participating in the following language instruction: *Take a look at this image (figure 1). What animal is pictured?*

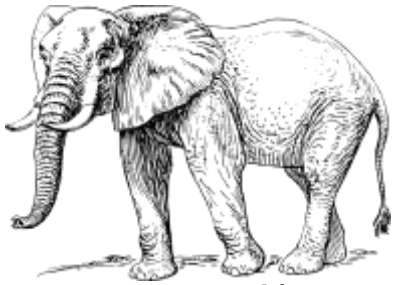

Figure 1. Image retrieved from http://www.freestockphotos.biz/stockphoto/11457

This is a tembo. Tembo is the Swahili word for elephant. The objective of this lesson is to learn the Swahili words for common animals of Tanzania.

A common response to the opening question from those reading this paper written in English is to respond with the English word *elephant*. Those of you who are multilingual may have produced your response by calling to mind the name for elephant in your first language and then translating that word into English, but likely only those who regularly speak Swahili responded to the question with *tembo*.

Now look at the next image (figure 2) and name the animal portrayed.

Figure 2. Retrieved from http://www.freestockphotos.biz/stockphoto/14211

Figure 3. Retrieved from http://www.freestockphotos.biz/stockphoto/14356

This is a chui-milia. Chui in Swahili means leopard. Milia means striped. A chui milia is a leopard with stripes or a tiger.

Now, look at figure 3 and think about how you will respond to the instruction to name it. *A punda milia is the Swahili word for zebra, a donkey with stripes.*

What happened when your attention was directed to the image of the tiger... and then to the zebra? As practiced learners, you may have hesitated before responding with the English name for the animals based on the stated lesson objective and the initial introduction to the term *tembo*. You may also have noticed the stripes of the animal in figure 3 and made connections to the word *milia* meaning striped.

Definition of Learning/Generation of Knowledge

Cognitive psychologists have developed theories to explain what is happening as each individual learns the new Swahili words; makes meaning out of the new content in an effort to recall the words at a later time. Generative leaning theory was developed to explain the cognitive processes that occur during learning. It defines learning as the generation of knowledge – "the creation of new understanding" (Grabowski, 2004). GLT is based on the assumption that a learner creates or produces new knowledge where "new" refers to knowledge new to an individual. In the lesson above, the Swahili words were new to the learner. The learner created ways of remembering the terms based on previous knowledge and experiences or based on the connections among the new information (e.g. *Milia* means striped. Tigers are *chui-milia*. Zebras are *punda-milia*.)

GLT is a functional model of learning that describes the processes of the brain during knowledge creation. Wittrock (1974/2010) described the process of learning as "a function of the abstract and distinctive, concrete associations which the learner generates between his prior experience, as it is stored in long-term memory, and the stimuli" (p. 41). His definition emphasizes connections between learner's current knowledge and new experiences or information (stimuli) in the creation of new understanding. In other words, learning occurs when new information is integrated and encoded through relating and connecting the new information to existing pre-conceptions and previous knowledge to create meaning. This new meaning is then organized and elaborated in long-term memory for recall and retrieval.

Mentally and Physically Engaged Learners

The active role of the learner in the processes of learning triggers the development of generative learning theory (Grabowski, 2004; Wittrock, 1974/2010; Wittrock, 1992). Wittrock did not view the learner as a passive recipient of knowledge. He proposed that the learner actively, both physically and mentally, engages with content to create new understanding. Learning occurs only when new information is organized, elaborated, or integrated into meaning by the individual. According to GLT, learning is more than the repetition of information as presented, the reproduction of a list, or the filing cabinet of received stimuli (Wittrock, 1974/2010). In comparison, Wittrock (1992) described the brain as a model builder by which the brain "actively controls the processes of generating meaning and plans of action that make sense of experience and that respond to perceived realities" (p. 531). The generative learning model describes the processes that the brain undergoes to make meaning of an event. Knowledge generation occurs through the active and dynamic engagement of the learner with the four process components.

Generative Learning Theory Processes

Wittrock's generative learning model has four components: motivational processes, learning processes, knowledge creation processes, and generation processes (Wittrock, 1974/2010; Wittrock 1992). These four processes result in the active and dynamic generation of meaning that "leads to the reorganization and reconceptualization and to elaborations and relations that increase understanding" (Wittrock, 1992, p. 532). In this way GLT differs from information processing as it extends beyond a change in the information for storage to learner generated new meaning as mediated by the four types of processes. The neural system of the brain "receive[s], selectively attend[s] to, and integrate[s] multisensory information in a self-directed manner (Wittrock, 1992, p. 535).

The four processes (Table 1) are described in a linear fashion similar to sensory input, short-term memory, and long-term memory described in other learning theories. However, the processes are tightly intertwined. For example, the knowledge creation processes and the generation processes are tandem processes in which the learner calls on past knowledge and experiences (memory) while developing connections to new information. These connections, prompted by the physical and mental activities of the learner with new content, and are internally labeled as they become an integrated part of memory.

Motivational processes. Wittrock based the four process components on his understanding of Luria's functional units of the brain (Wittrock, 1974/2010). Motivational processes and learning processes are associated with Luria's arousal and attention unit of the brain (Lee, Lim, & Grabowski, 2008). This functional unit serves to make the learner aware of stimuli in the environment and decide what to acknowledge and what to ignore (Languis & Miller, 1992). Learner's motivational processes, such as interest and sense of control over learning, stimulate the learner to respond to new information. In the lesson on Swahili terms for animals, learners were presented with the image of an elephant. The learner made a choice to attend or not attend to the image (visual input) and the question posed (auditory input) and that choice was integral to the learning of the new content.

Learning processes. A learner's motivational processes and learning processes are nearly simultaneous. Motivational processes activate learning processes that draw learner's attention to the new information once it is acknowledged. Learning processes then direct the learner's attention to the new information. For example, after the image of the elephant and the question grabbed the learner's attention, the learner mentally began to focus on the content presented. If a neighboring student made a comment, the learner's attention may have been diverted to the content of the comment. In this way, attention may vary during the learning process as the learner 'tunes in' or 'tunes out' the multitude of stimuli within the environment. Learning processes are those individual behaviors and preferences that regulate attention to new content or information.

Knowledge creation processes. Based on existing knowledge, beliefs, and values, the learner who is attending to the stimulus begins to build a new model incorporating the new information. These knowledge creation processes are based on Luria's second functional brain unit known as sensory input and integration (Languis & Miller, 1992). The new information is now being received, analyzed, and stored. Sequences and patterns are developed that reflect the learner's previous knowledge and experience (Wittrock, 1992). The learner's knowledge creation processes qualify relationships between the new content and prior knowledge. Connections and relationships are created during the knowledge creation process. In the case of learning the Swahili terms for elephant, tiger, and zebra, learners may have brought to mind a trip to the zoo; the cartoon image of Shere Khan from Kipling's *Jungle Book*; the recognition that *chui-milia* and *punda milia* are both striped, or the similarity of the words *temple* and *tembo*. Wittrock proposed that knowledge creation processes, including metacognition, develop relationships between and among ideas determining the quality of the meaning made by the learner.

Generation processes. Wittrock referred to the process of coding or integrating the information as the generation process. Generative learning processes are mapped to Luria's third functional unit of the brain called the executive planning and organizing unit (Languis & Miller, 1992). In this process the learner mentally labels the links between connections and relationships as information is organized and integrated

for later recall and retrieval. The learners listening to the word *chui-milia* may make a connection to the familiar English word "chew" meaning to use one's teeth to break food into smaller pieces. The connection to chewing and teeth may then be drawn to the carnivore and predator, *chui-milia* or tiger. This connection is then used when the learner is asked to provide the Swahili term for tiger.

Table 1. Four Process Components of Generative Learning Theory

	Motivational Processes	Learning Processes	Knowledge Creation Processes	Generation Processes
Brain Functional Unit	Arousal and attention	Arousal and attention	Sensory input and integration	Executive planning and organization
Learner Action	Selectively acknowledge new content based on interest and sense of control	Focus attention on and respond to the new content that has been acknowledged	Iteratively combine and compare new content to existing knowledge	Create new relationships through integration, organization, reconceptualization and elaboration
Determines	Recognition of stimulus/new content and whether generation occurs	Decision to code and integrate the new information	Quality and type of connections generated based on memory, beliefs, and values	Level of comprehension Success of recall and retrieval of new content
Characteristics to Promote Process	Promote learner self-concept Emphasize learner's control and responsibility for learning Relate learning to effort	Gain learner attention and focus on meaning of content Relate relevance of topic to the learner Provide behavioral learner objectives	Draw upon learner's previous knowledge and interest Facilitate learner metacognition Monitor learners preconceptions & misconceptions	Provide opportunities for learner to manipulate information and draw relationships

Based on these four processes, a learning resource 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" can be supportive of meaning-making – learning (Lee, Lim, & Grabowski, 2008, p. 112). Scholars have studied and continue to study generative learning processes individually. A sample of these studies is presented next in support of GLT.

Research Studies on Generative Learning

GLT has been well supported by studies in multiple disciplines with learners of different ages and levels. The body of literature on GLT has dealt with the effects of generation of meaningful relationships within new content and between new content and previous knowledge and experience. Initially, GLT was studied using transfer designs that emphasized learners' prior learning as it related to new content (Doctorow, Wittrock, & Marks, 1978; Wittrock, 1974/2010; Wittrock & Carter, 1975). These studies examined learner gains in recall when generative strategies of summarizing and headings were used in instruction. Both elementary school and undergraduate students using generative strategies in reading and science out performed control groups who were not prompted to employ generative strategies.

The focus of the studies was the reaction to new content and subsequent transfer to learner beliefs, values, and prior experiences. Overall, these initial studies supported a generative learning model and called for additional research in how learners relate new information to their existing understanding.

Continued studies of generative learning examined the use of two types of generative learning strategies (see Bonn & Grabowski, 2001). These strategies can be divided into coding strategies where learners create relationships among aspects of the content and integration strategies where learners relate new information to prior knowledge. Coding strategies include note taking, adjunct questions, underlining, organization headings, concept maps, and graphic organizers. Elaborations, imaging, interpretations, analogies, and summaries are generative integration strategies that have been studied in multiple content areas. Most study designs have been quasi-experimental using convenience samples of students randomly assigned to control groups and experimental groups.

Studies on coding techniques. Studies examining *coding techniques* of underlining and note taking have shown improved comprehension; however, debate as to the extent that these techniques are generative is ongoing (see Davis & Hult, 1997; Peper & Mayer, 1986; Rickards & August, 1975). The debate centers around whether note taking involves the creation of new meaning. Researchers have found that the quality of the notes, the extent to which the learner elaborates while note taking, and the use of notes for review affect the learning outcomes. Peper and Mayer (1986) examined the encoding process of note taking of students learning about car engines. Their findings indicated generation of external connections and showed a positive effect of note taking on long term retention that does not occur for short term fact recall (Peper & Mayer, 1986). Interestingly, Barnett, DiVesta, and Rogosinski (1981) found that when learners elaborated instructor provided notes, they performed better than students who used self-generated notes. Together, these studies suggest that physically interacting with content using note taking techniques does appear to help learners encode new information, however different techniques have varying levels of success related to mental actions and later recall.

The research on the use of *questions* to trigger generation of new knowledge has examined the timing of questions, frequency of questions, type of questions, type of expected learner response to questions, type of feedback, and the type of learning, incidental or intentional (see Anderson & Biddle, 1975; Grabowski, 2004; Rickards, 1979). In general, requiring learners to overtly respond to questions, using more general questions than detailed, and providing questions after presentation of content were found to enhance comprehension (organizing, integrating, understanding of new information).

Organizers such as concept maps and headings were also found to enhance comprehension. The interventions were designed to enhance learning by calling attention to relationships within new content and between new content and prior knowledge. Learner attributes, structure of content, and source of the organizer produced varying results on recall and retention. For example, instructor generated concept maps were found to be more effective than student generated concept maps (Smith & Dwyer, 1995). The results indicated that the generation process when using these strategies was not clearly understood.

***Studies on integration techniques*.** Integration techniques involve the connection of new content with prior knowledge. Learners *label* connections based on their beliefs, values, and preconceptions adding to their existing knowledge. Learners who *create* their own images and analogies benefited in terms of long-term retention when compared to learners who used instructor generated techniques (see Grabowski, 2004). For example, elementary students who drew images and created analogies after reading stories, showed higher levels of comprehension than those who were not instructed to use generative strategies (Linden & Wittrock, 1981). Studies that examined the use of *elaborations* were less conclusive including computer assisted instruction training where no differences in learning were associated with the source of the elaborations (Johnsey, Morrison, & Ross, 1992).

Higher order thinking and self-regulation. More recently, studies have explored higher order thinking and self-regulation of learning as described by GLT. Studies examining higher order thinking have focused on learner *organization strategies* with concept maps (Lee & Nelson, 2005). Lee & Nelson (2005) found that of the learners who had previous topic knowledge, those who generated their own maps

outperformed those who were given instructor-generated maps. The opposite was true for learners with little to no prior knowledge of the topic, concept mapping activities were less beneficial than viewing an instructor-generated map. In a study of undergraduate students, Lee, Lim, & Grabowski (2010) suggested that a learner's metacognitive and self-regulation capacities acted to inform, manage, and monitor the generation process of the learner.

Research based on GLT has focused on the use of generative learning strategies to enhance learner knowledge gain and deepen the learner's level of understanding. Studies examined specific levels of knowledge acquisition: recall, comprehension, and higher order thinking skills. These studies yielded mixed results based on learning strategy used, learner ability, and level of content to be mastered. Results often varied based on the nature of the transfer task: short-term recall or long-term retention. However, most studies showed an increase in learning gain when learners were physically and mentally engaged with the content (Lee, Lim, & Grabowski, 2008). These findings support the assumption of active learner engagement as presented in GLT. This suggests that learning resources can have enhanced value by incorporated tenets of GLT.

Learning Resources Informed by GLT – Possibilities

Instruction is a compilation of informational, instructional, and learning resources (Grabowski & Small, 1997), each providing a building block upon which to purposively support learning. Whereas informational and instructional resources support the overall content and direction of instruction, the learning resources, whether in analogue, digital, or social/human format fully engage learners in learning processes. By integrating GLT tenets into learning resources students can be engaged physically and cognitively with content to help them generate new knowledge. GLT suggests that features of learning resources that could be of great value to learners will engage them in activities like specified note taking, elaborating on content, labeling relationships between new content and background knowledge, and creating images and analogies that indicate understanding to support learners in coding new information. Activities that engage learners in responding to questions, provided organizers, and attending to relationships between new concepts and prior knowledge can support learners in generating new connections while studying content. Embedding these types of prompts into the learning resources themselves (or as integrated instructional prompts) therefore may enhance the abilities for learning resources to aid learners in deep learning. The varied research results suggest that additional research is needed to examine the model as a whole and the relationships between the four components as articulated in learning resources.

Future Research

The four processes of GLT act in conjunction with one another to create relationships; however, each of these processes has been studied in isolation and study results have been mixed. Evidence has indicated that when learners are actively and dynamically involved in the creation of knowledge, learning outcomes are enhanced. Motivation process and learning process components of GLT have been studied to a lesser extent. For example, the effect of feedback on generative learning activities has not been well defined for learner-generated activities. Further research exploring the attention and intention of the learner in a generative learning environment would provide useful information for developing instruction.

The combined role of motivational processes, learning processes, knowledge creation processes, and generative processes is largely unstudied, yet individually suggest guidelines to inform the design of resources to support learning. GLT advocates that learning occurs when these processes are engaged together. They are part of a whole in which all parts are required for learning to occur. Conducting research that incorporates methods to measure all four components within a single study may further inform GLT and help in the development of principles and guidelines to create instruction and instructional resources that support deep learning.

Synthesis

GLT emphasizes the role that existing knowledge, values, and beliefs of the learner play in the creation of new meaning and understanding. The learner actively processes new content to create connections between new information and existing pre-conceptions and experiences. In this way meaning is developed, or generated, that is unique to the individual. GLT suggests that intentionality in learning is shared equally between the instructor and learner. Thus, instruction that involves interaction focused on engaging the learner with the content is believed to facilitate a learner's creation of relationships.

Instructional designers and informed educators create learning resources based on research and understanding of how individuals learn. GLT suggests that learning environments consist of student-centric learning with the instructor as a guide supporting the learning process. Learning resources that gain the learner's attention; address learner's perceived role and control in learning, and engage the learner in organizing and building relationships between new content and prior knowledge have the potential to enhance meaning-making. Designing learning resources based on GLT suggests that such resources should engage learners physically with content while prompting their thinking to organize and integrate new content with existing knowledge structures.

Learners actively engage both physically and cognitively with content during learning activities to organize and integrate new content into meaningful and structured knowledge. Evidence such as increased reading comprehension with the use of headings (Doctorow, Wittrock, & Marks, 1978); variation in level of learning based on the order of generative strategies (Ritchie & Volkl, 2000), and varied comprehension based on degree of learner's prior knowledge (McKeague & DiVesta, 1996) support this theory. However, generative learning theory is only one dimension that may suggest dimensions of resources that can help facilitate deep learning. Other factors may include the abilities of learning resources to engage learners in cognitive flexibility thinking (Cheng & Koszalka, 2016), reflection (Koszalka, 2016), and at appropriate types and levels of learning suggested by expected learning outcomes (Yang & Koszalka, 2016). The RIDLR team is developing and researching learning resources that incorporate multiple dimensions to support higher order thinking and the development of learning assessments.

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