COGNITIVE CONCEPTIONS OF LEARNING: IMPLICATIONS FOR TEACHING AND LEARNING

by

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Abstract

The advent of modern-day cognitive psychology has produced a substantial change in the way we view learning. Learning is now viewed as an active process whereby learners generate or construct meaning from information by accessing and applying existing knowledge. As a result, much of recent educational research has focused on the effectiveness of cognitive learning strategies. This paper discusses the findings of research on learning and memory that led to new conceptions of learning. The findings of studies on the use of cognitive learning strategies are also presented. In addition, implications of such findings on the approach to teaching and learning are discussed.

Introduction

Research in the field of cognitive psychology emerged in the late 1950s as a result of the failure of behaviorism to provide adequate explanation of human cognition. This field of study has produced rich descriptions of the mental processes and representations that underlie learning and memory. Studies on how incoming information is processed, stored and retrieved have led to substantial changes in psychological conceptions of the learning process. The traditional, behaviorist views of learning, which permeated both psychology and education for at least half a century, viewed learning as a passive, receptive, and reproductive process. The role of the teacher, according to this view, is to dispense information that students can absorb in a more-or-less passive manner and then reproduce it at the appropriate time. When the student makes an appropriate response, it should be reinforced by an external stimulus or event. This view has now been replaced by cognitive views of learning which regard the learner's role as an active one. The cognitive view of learning emphasizes that learning takes place through the active participation of the learner in cognitive operations such as making sense of new information, and sorting and organizing new information. Learning is believed to take place within a context of previously acquired knowledge. What were the events which led to these new conceptions of learning? This paper presents cognitive psychologists' findings on learning and memory and the impact of such findings on psychological conceptions of learning.

Learning and Memory

The behaviorist (or S-R) approach to learning focused on how presentation of material influenced behavior. As Farnham-Diggory (1977, p.128) pointed out, the S-R approach is based on the idea that "a stimulus goes in, a response comes out, and what happens in between is summarized by a hyphen". In contrast, the cognitive approach to learning seeks to understand how incoming information is processed and structured in memory. The desire to find the answer to the question "What happens in the mind during learning?" led cognitive psychologists to investigate the cognitive processes that the learner engages in during learning. The term "cognitive processes" refers to all the processes by which the sensory input is transformed, reduced, stored, recovered and used (Neisser, 1967). Studies conducted to find out more about these cognitive processes included studies on levels of processing, encoding specificity, information processing and working memory, knowledge representation, and interference and forgetting.

- **Levels of Processing of Information**

  A series of studies by Craik and Lockhart (1972) and Craik and Tulving (1975) (cited in Reed, 1992) showed that recall increases as depth of processing increases. Semantic processing (attending to the meaning) produces richer and more discriminative memory traces than phonemic processing (attending to the sound) or structural processing (attending to the physical nature) of the verbal material.

  Deep levels of processing enhance recall because of two factors: distinctiveness and elaboration. Distinctiveness refers to how precisely an item is encoded (Benjafield, 1992) while elaboration refers to the amount of extra processing one does that results in additional and related material. Elaboration involves reorganizing the material to fit in with what is already known. Elaboration increases the distinctiveness of the item in memory and enhances recall for the material learned.

- **Encoding Specificity**

  It has also been found that appropriate structuring or organization of information during learning improves retention and aids retrieval of information. Tulving and Thomson (1973) (cited in Reed, 1992, p.137) put forward the encoding specificity principle, which states that "specific encoding operations performed on what is perceived determines what is stored, and what is stored determines what retrieval cues are effective in producing access to what is stored". There is interaction between retrieval cues and encoding operations such that retrieval cues that correspond to the way the information is encoded facilitates its recall. This means that the learner should create memory codes that correspond to how the material will eventually be used. In most learning situations, this means semantic processing of information as learners are required to recall, recognize or apply semantic information in answering multiple-choice, essay and problem-solving questions.

- **Information Processing and Working Memory**

Various models have been put forward to explain how information is processed. The information processing approach, which dominated cognitive psychology in the 1960s and 1970s, remains strong and influential today (Galotti, 1994). According to Leahey and Harris (1993), the human mind is rather like a computer, accepting input through perception, storing it in memory, processing it in thought, and acting on it in making decisions. Information-processing theorists believe that the human brain processes and stores information in three different systems: the sensory or perceptual system receives information and transmits this to the short-term memory (STM). Signals received by the sensory perceptual system or sensory memory are quickly lost (one second or less) unless transmitted to the STM where they can be retained for half a minute or more. The information fades away unless it is encoded and passed on to the long-term memory (LTM) where it may reside until death.

The concept of STM functioning as a working memory was introduced by Allan Baddeley. Working memory (WM) is the system that performs the task of temporarily manipulating information from both the environment and LTM whenever a person tries to learn new information, make decisions, retrieve information from the LTM, or solve problems. However the STM has a limited capacity of up to 7 ± 2 chunks of information only. The size of each chunk depends on the knowledge stored in the LTM. If knowledge has been organized in large familiar chunks, then the total amount of information that can be retrieved into the WM will be much more. This means that the organization of knowledge into meaningful or familiar chunks during encoding and subsequent storage in LTM will ensure a "larger" working memory capacity and therefore results in more efficient problem-solving. This phenomenon has been observed in studies involving chess players (de Groot, 1965; Chase & Simon, 1973)(cited in Frederiksen, 1984). Grand Masters were able to recall correctly 90% of the 25 pieces on a chess board (through forming chunks of 5–6 pieces each) while novice chess players could only recall correctly 5-6 pieces as they remembered it piece by piece.

Apart from the above sequential symbol system, another system called the parallel-distributed processing (PDP) system has been put forward by Rumelhart and Norman to explain how cognition takes place. The PDP system argues that cognitive processing can be understood in terms of mutually excitatory networks that link together neuron-like units. Research on this is still in progress (McClelland & Rumelhart, 1995). As yet PDP cannot account for certain memory phenomena such as why we can handle different instances of the same concept at the same time and how we are able to have a number of mental variables during problem solving (Matlin, 1994).

- **Knowledge Representation in Long-Term Memory**

Studies on knowledge representation in LTM have resulted in a variety of models being proposed on how knowledge is mentally represented and organized. According to Stewart (1985), various theories such as semantic network theory (Hierarchical Network Model by Collins & Quillian, 1969; Spreading Activation Model by Collins & Loftus, 1975) and schema theory

(Rumelhart, 1975) that have been put forth suggest that the psychological content of memory seems to interconnect and overlap in elaborate ways. Semantic networks are models of how conceptual information is probably stored in an individual's LTM. A network consists of a set of nodes (concepts) and relational lines that connect the concepts. According to the Hierarchical Network Model, concepts are stored hierarchically, with meaningful associations between concepts. In the Spreading Activation Model, concepts are stored non-hierarchically, with highly related concepts located close together. This probably explains why forming meaningful relationships between concepts in the material learned facilitates understanding and recall.

The schema theory is a more elaborate view of memory organization. Schemata, as explained by Stewart, Finley and Yarroch (1982), are, in a sense, "packages" of knowledge of particular objects, events, or general classes of objects or events. The term schema is usually meant to refer to something larger than an individual concept. A schema is thought to be a large unit of organized information used for representing concepts, situations, events and actions in memory. Learning results in the construction and elaboration of schemata, which serve to organize knowledge and facilitate recall and further learning. Schemata play an important role in perception and pattern recognition as we try to identify objects we see before us or in memory and as we call to mind relevant information to help us interpret current information and make decisions about what to do next. The schema theory provides a theoretical explanation of how learning and recall in some cases is much easier due to the presence of the relevant schemata as recognition devices.

- **Interference and Forgetting**

  Studies which have been carried out to explain forgetting also point to the importance of effective processing of information during learning. As noted by Galotti (1994), early researchers such as Peterson and Peterson (1959) suggested that forgetting could be due to a process of passive decay. Items that are not recalled or studied for a period of time tend to lose strength in memory as a result of an automatic process of decay. In order to reduce this form of forgetting, it is important to frequently apply and review facts and ideas. However, decay does not seem to be the main reason for forgetting. The alternative view is that forgetting is caused by interference. Galotti (1994) cited a number of studies (Wickens, Born & Allen, 1963; Waugh & Norman, 1965) which showed that interference, not decay, accounts for forgetting. There are two types of interference: proactive interference is when something already learned interferes with remembering something new, and retroactive interference is when learning something new interferes with remembering something already learned. In both types of interference the amount of interference is a function of similarity. The more similar two items are, the more they interfere with each other. One way to reduce forgetting due to interference is to stress meaningfulness and distinctiveness during learning and refrain from using rote-memorization, which does not involve meaningful encoding of information.

Cognitive Conceptions of Learning

The above findings on learning and memory have led to substantial changes in psychological conceptions of human learning. According to Shuell (1993) learning is considered to be an active, constructive, cumulative, self-regulated, and goal-oriented process in which the learner plays a critical role. Learning is active in that the learner must carry out cognitive operations on the newly presented information. The way the learner processes the information determines the quality of learning. Shuell (1987, p. 243) pointed out that "what and how much an individual learns depends on the activities in which he or she engages; learning involves more than passively responding to the environment." As has been discussed earlier, performing cognitive operations such as semantic processing, elaborative processing, organizing and categorizing enhances learning.

Learning is constructive in that new information must be elaborated upon and related to other information. In recent years, educational research has centered on the constructivist approach to learning. According to this approach, learning comes about through the learner's active involvement in knowledge construction (Driver, 1989). During constructivist learning, knowledge is not passively received, but is actively built up by the cognizing subject. Learning is accomplished by constructing and elaborating schemes based on experiences; it is very much a personal matter (Wheatley, 1991).

Learning is cumulative in that all new learning builds upon and utilizes the learner's prior knowledge in ways that determine what and how much is learned. Learning as a process of building upon the knowledge base was emphasized by Ausubel (1968) who wrote, "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."

Learning is self-regulated in that the learner must have the capability to mobilize, direct, and sustain his or her learning efforts towards achieving a goal. It includes processes like planning and managing time, attending to and concentrating on instruction, organizing, rehearsing, coding information strategically, establishing a productive work environment, and using social resources effectively (Schunk & Zimmerman, 1997).

Finally, learning is goal-oriented in that it is most likely to be successful if the learner is aware of the goal toward which he or she is working and possesses expectations that are appropriate for attaining the desired outcome (Shuell, 1992). The emphasis here is on the need for the student to formulate appropriate goals. According to the cognitive view of learning, the mere statement of objectives or goals by the teacher is not enough to guarantee effective learning. Unless the learner understands and adopts the objectives or goals as his own, they will have little, if any, impact on the learning process. In the words of Brown (1990, p. 268), "learning is much more an evolutionary, sense-making, experiential process of development than of simple acquisition."

Cognitive Learning Strategies

In light of the above new conceptions of human learning, much of recent research aimed at finding ways to enhance student learning has focused on the use of cognitive learning strategies. McCrindle and Christensen (1995) reported that a growing body

of research has shown that the nature of cognitive strategies used by the individual during the learning process strongly influences the outcome of the learner's activity.

Weinstein and Mayer (1986) identified three groups of cognitive strategies: rehearsal, organization and elaboration strategies. Examples of rehearsal strategies are oral repetition, underlining, copying, and making selective verbatim notes. Examples of organizational strategies are grouping, sorting, categorizing, development of hierarchies and constructing networks, while elaboration strategies include mental imagery, paraphrasing text, summarizing, creating analogies, generative note-taking, and self-questioning. There is evidence to show that the use of organizational and elaboration strategies produce better learning: King (1994) found that encouraging students to generate questions and explanations for the text resulted in enhanced learning; Chi, Leeuw, Chiu and Lavancher (1994) investigated the effect of asking students to self-explain after reading each line of a passage on the human circulatory system. These students had a greater gain from the pretest to posttest than the control group students; Pankratius (1990) found that students who learned physics through concept mapping scored significantly higher marks than their counterparts who did not concept-map; McCrindle and Christensen (1995) found that students who employed organizational and elaboration strategies (reflective writing/learning journals) during learning performed better in their final examinations than those who used rehearsal strategies. The above findings show that the quality of learning is related to the type of study strategies employed. According to Lonka, Lindblom-Ylainne and Maury (1994), deep-level, knowledge transforming strategies which involve the learner in active constructive processing, elaboration, or efforts to understand produce greater learning than surface-level reproduction strategies such as maintenance rehearsal, underlining, copying, or reading already-generated material.

Implications for Teaching and Learning

The realization that learning is an active process requires a change not only in the way students approach learning, but also in the way teachers approach teaching. A good teacher is not merely a person who can articulate a large number of related facts and ideas (although a sound understanding of the subject matter being taught is certainly essential); a good teacher is one who is able to get students to engage in learning activities that are likely to result in meaningful learning. The teacher's role should be one of: 1) determining which learning tasks are appropriate for the students to work on and providing the learning environment for it, 2) providing cues as to what is important in the material being learned and the manner in which it can be processed, 3) monitoring their progress to ensure that the desired learning is taking place, 4) repeating the cycle if the learning process is judged to be ineffective, and 5) relating to students in personal ways that affect their feelings of self-efficacy, motivation and personal goals. Since learning is cumulative in nature, with new learning building on prior learning, teachers also need to provide links to the real-world knowledge of students by relating the information with daily experiences.

Meanwhile, the student's role should be one of taking an active part in the learning process. Students should have a personal sense of commitment towards attaining a goal and work objectively towards it through planning, organizing, rehearsing, reflecting and seeking social assistance. Apart from self-regulating their learning, they should also expend more effort at cognitive processing of information during learning.

These include: 1) semantic processing of information (processing for meaning), 2) distinctive elaboration (differentiating between concepts, adding to and relating information), and 3) organization of information into meaningful chunks (forming hierarchical networks, sorting into categories). Students should realize that learning is an individual responsibility that requires mental effort on the part of the learner.

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