3.2

Cognitivism

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Learning Theory Cognitivism

Cognitive learning theories cover a wide range of ideas from the work of many researchers. It is a continually developing field which has influenced and been influenced by the developments in different fields including instructional design, developmental psychology, cognitive psychology, and increasingly cognitive neuropsychology. Cognitive learning theories focus on the ability of students to guide their own learning using mental strategies. The purpose of this chapter is to (a) briefly explore the growth of cognitivism, (b) explain some of the relevant cognitive processes identified within cognitivism, (c) provide an overview of several cognitive learning theories, and (d) describe the relevance of cognitivism to instructional design practices. These areas will provide an instructional design student with knowledge of theories that can be applied in situations for learners with varied learning needs.

Growth of Cognitivism

Cognitivist learning theories are understood to have stemmed from the inadequacies of the behaviorist learning theories of strict stimulus and response training to fully explain how learning occurs. Petri and Mishkin (1994) point to the work of researchers Edward Tolman, Wolfgang Kohler, and Ivan Krechevsky on the role of expectations, insight, purpose, and hypothesis making in the early 1920s and 30s as the earliest forays into cognitivist research. However, it was not until the 1950s that cognitive theories began to gain discernible traction and attention.

The definition and scope of cognitivism has evolved over the years. Early studies of cognition explored the active acquisition of knowledge as opposed to the more passive learner approach of behaviorism (Woolfolk, 2015). According to more recent views such as those of Ertmer and Newby (1994), "cognitive theories focus on the conceptualization of a student's learning processes and address issues of how information is received, organized, stored, and retrieved by the mind" (p. 58). An early model of cognitivism, known as the two-store or dual memory model, refers to the interactions between working memory and long-term memory. The two-store (dual) model is now seen as simplistic and incomplete but serves as a starting point for understanding cognitive learning theories. As the field of cognitivism has expanded, more theories have been developed so that there is no universal cognitive model or theory of learning accepted by all cognitive scientists.

Cognitive Processes

In this section I will briefly explain the cognitive processes related to the two-store (dual) memory model including (a) perception, (b) executive processes, (c) working memory, (d) encoding, and (e) long-term memory. These do not include all of the cognitive processes involved in learning, but these are the ones most commonly addressed in the cognitivist view of learning. I acknowledge that each process is complex and have entire books written about them. However, I will attempt to provide a working definition and description based on current knowledge that is most relevant to cognitivist learning theories.

Perception

The process of receiving information begins with some sort of sensory input: the sound of a bell, the smell of a rose, the touch of a feather, the taste of honey, or the sight of a friend. Each of the five sensory systems in our bodies has its own complex pathway for registering and assigning meaning to, or perceiving, that input. It is generally based on context and patterns of what is already known. The body receives large amounts of sensory data constantly since we touch, see, hear, taste, and smell all the time, even though we are not conscious to all of it at once. Sensory information stays only a very short time in the sensory register, though time estimates vary between less than a second to up to three seconds. Then the information is transferred to short-term or working memory (Schunk, 2012 p. 165; Woolfolk, 2015, p. 294).

Executive processes

Executive, or control, processes “regulate the flow of information throughout the information processing system” (Schunk, 2012, p. 166). These include the conscious processes and effort a person exerts in managing new information as it is presented including directing attention, planning next steps, and retrieving information from long-term memory for current use (Woolfolk, 2015, p. 298). It is often linked to working memory but has influence in all parts of the two-store model. Executive processes are also used to monitor understanding, select learning strategies, and regulate motivation. I will focus mainly on attention here, as it fits chronologically in the two-store model, but will keep in mind that cognitivists believe that learners play a conscious, active role in the learning process, so the executive control functions affect each stage of the process.

Attention is selective, which allows us, with effort, to ignore or acknowledge pertinent sensory input. We would be overwhelmed if we tried to pay attention to every bit of competing sensory information at once. For example, in a classroom, one could see the notes on the board, the teacher’s new hairstyle, and the current heart-throb sitting 2 seats over, all while feeling an itchy shirt tag, and smelling the students returning from gym. Cutting through all of the sensory input, one needs to decide where to focus attention. There are individual differences in one’s ability to initiate and maintain attention, based on age, motivation, self-control, learning disabilities, and familiarity with the subject matter. The more familiar someone is with a skill or context, the less conscious attention they need to exert in processing and the more capacity they have to take in new information (Schunk, 2012).

Short-term or working memory

While short-term and working memory are not considered synonymous by all researchers, they are often used interchangeably. Schunk (2012) says that short-term memory is “a working memory and corresponds roughly to awareness, or what one is conscious of at a given moment” (p.179). Woolfolk (2015) distinguishes the two in that working memory “includes both temporary storage and active processing,” while short-term memory is usually referred to only as temporary storage of information (p. 297). It is generally agreed upon that short-term and working memory are limited in both capacity and duration, and information will be lost if it is not constantly rehearsed or transferred to long-term memory. Chunking, or segmenting, information into smaller pieces or groups may help reduce the load on working memory. For example, instead of one long string of numbers, telephone numbers are segmented into three sections.

Based on current understanding, there are four elements in working memory that process different types of sensory input: the central executive, which controls attention and mental resources; the phonological loop, which processes verbal and auditory information; the visuospatial sketchpad, which works on visual and spatial information; and the episodic buffer, which integrates information from the previous processors with information from long-term memory to make sense of it all (Woolfolk, 2015, p. 298). The processors can be used strategically, for instance to memorize a phone number given verbally. I would exert my executive control by constantly repeating the number out loud, using the phonological loop to rehearse until I could write it down, creating a visual image. I could then continue to rehearse the number out loud while visualizing the number in my head, drawing on the visuospatial sketchpad. I could use my prior knowledge of ZIP codes or number patterns to make connections with more familiar numbers until the number was memorized. These four elements of working memory are important for an instructional designer to understand as they consider strategies to assist learners. This leads us to a further discussion of encoding.

Encoding

Encoding is the process of integrating new information processed in the working memory with what is already known to facilitate storage in the long-term memory. Encoding is influenced by organization, elaboration, and schema (Schunk, 2012, p. 187). For cognitivist researchers, encoding is where the magic happens. This is where all of the cognitive processes and executive control functions work together to “learn” new information and store it for future use.

Gestalt theory developed in the early 1900s refers to our “tendency to organize sensory information into patterns or relationships” (Woolfolk, 2015, p. 294). While the Gestalt theory is now essentially disproved, it provided early insight into human perception, showed that organized material is easier to recall, and revealed that humans will often impose order and meaning when there is none apparent (Schunk, 2012). Organizational strategies include creating hierarchies, mnemonic techniques, and mental imagery. Organization of material enhances memory, because it connects new information to what is already known, and when one piece of information is activated, or cued, it will activate connected information as well.

“Elaboration is the process of expanding upon new information by adding to it or linking it to what one knows” (Schunk, 2012, p. 188). Mnemonic devices can assist with elaboration by giving meaning to something easily remembered, such as using the first letter of the order of operations in math: Please Excuse My Dear Aunt Sally (Parentheses, Exponents, Multiplication, Division, Addition, Subtraction). I used elaboration in memorizing the license plate number on my old car, 6AT1830. There are six children in my family, so I linked that information to the six. AT formed the word “at,” and 1830 could be the military time for 6:30. I asked myself the question, “How many for dinner?” The answer is 6 at 6:30 (or 1830). It may seem a convoluted process to memorize, but it has stuck, so much so that after I bought a new car and switched license plates, I still try to give the old plate number. The process of elaborating new information with meaningful knowledge increases the likelihood that it will be remembered.

Schemas or schemata are personalized organizational structures. They encompass our general knowledge of specific situations that are used to plan our actions and interactions. They often prescribe a routine of actions based on our past experience (Schunk, 2012, p. 189). For example, a schema could be the process of ordering fast food. For one person, the schema may include using the drive through, carefully considering different options on the menu, ordering their meal, pulling forward, paying, and then eating on the road. The schema for another customer might include going inside the restaurant, ordering the same items as always, chatting with the employees, and sitting down to eat. Any schema about ordering fast food allows a person to go into the situation with some prior knowledge and expectations of the process.

Schemas can also assist in processing new information using a pre-existing or familiar structure. For example, a schema for a Hollywood romantic comedy would contain consistent elements. When watching the newly released summer blockbuster, a moviegoer would likely recognize familiar types of characters, themes, and plot points: the heroine, the love interest, the misunderstanding or obstacle to the relationship, and the eventual happy ending. Schemas can help learners encode by integrating new information with familiar knowledge and structure.

Long-term memory

Petri and Mishkin (1994) define memory as “the ability to store sensory information for later retrieval as images, thoughts and idea” (p. 33). What is referred to as memory in common speech generally means long-term memory where images, thoughts, and ideas are stored for greater lengths of time. While short-term memory is limited in duration and capacity, long-term memory is, theoretically, unlimited in both. Information is generally stored in long-term memory as verbal representations, though as ideas rather than in specific sentences. For example, when trying to recall something my friend said yesterday, I am likely to remember the idea and recreate it in my own words instead of repeating my friend's words verbatim. Information can also be stored as visual images. Stored information is accessed through cues, such as a question or request for information.

It is important for instructional designers to know that information is more easily accessed in long-term memory when it has been associated with meaningful connections, organized, and elaborated sufficiently (Schunk, 2012, p. 194). Frequent retrieval of information through review strengthens a learner's ability to access that information in the future. The more automatically the information can be accessed, the more easily it can be retrieved and the more useful it can be in learning future related concepts.

Cognitive Theories of Learning

There are multiple theories of both learning and the cognitive processes themselves. The theories of learning presented here are some of the most well known and applicable in the field of instructional design.

Information Processing Theories

Information processing theories are varied but generally deal with how people attend to environmental events, encode information to be learned and relate it to knowledge in memory, store new knowledge in memory, and retrieve it as needed (Shuell, 1986). The computer information processing system of receiving information (input), storing information (encoding), and retrieving that information as directed (output) was an early analogy for how a human mind processes information, as was discussed earlier as the two-store model. This analogy has gained complexity over time, but information processing theorists generally assume that information processing in human minds occurs in stages between receiving a stimulus (input) and producing a response (output), though theorists differ in how closely they adhere to the computer model. The form or mental representation of the information differs depending on the stage of processing. Another assumption is "that information processing is involved in all cognitive activities: perceiving, rehearsing, thinking, problem solving, remembering, forgetting, and imaging" (Schunk, 2012, p.165). Information processing theory can be useful to instructional designers in learning situations requiring the recall of specific information. Instructional designers could focus on encouraging strategies to maximize encoding and retrieval.

Cognitive Load Theory

Cognitive load theory proposes that a finite amount of information can be processed in the mind at one time, based on the limits of perception, attention, and working memory (Schunk, 2012, pp. 223-224). Drinking from a firehose is an apt analogy in that the demands of an activity can exceed the capacity of a person to absorb what is being given. Sweller (2011) suggests that long-term memory is of primary importance to the nature of learning because "we use it to determine the bulk of our activity." Experts are those who have stored large amounts of information about a certain topic in long-term memory and can draw upon it to solve problems. The problem, therefore, is to efficiently transfer information through the biological constraints of our short-term or working memory into long-term memory.

All new information exerts some load on our working memory. Cognitive load theorists recognize two main types of load: intrinsic and extrinsic. An intrinsic cognitive load is related to the complexity of the information itself compared to the expertise of the learner and can only be changed when the learners have the necessary cognitive processing strategies (Sweller, 2011). Extrinsic load refers to the way in which "material is presented or the activities required of the learner" (Schunk, 2012, p. 224).

Scaffolding and the use of schema can help reduce cognitive load in instruction as it allows learners to reduce the demands on their cognitive resources, especially working memory. This can be accomplished by providing clear instruction, reducing redundant information, presenting information both visually and aurally, allowing students to learn elements separately (e.g. individual chemical symbols), demonstrating problem solving, and removing more elementary information from explanations to students with higher levels of expertise (Sweller, 2011).

Self-Regulated Learning

Self-regulation as defined by Zimmerman (2001) "refers to the self-directive process through which learners transform their mental abilities into task-related academic skills" (p. 1). Like other cognitivist theories, this assumes that students are actively involved in the learning process, showing initiative, perseverance, and adaptive skills in pursuing the learning, be it on their own or through social interaction (Zimmerman, 2001). Research into self-regulated learning (SRL) began in the mid-1980s and has grown to encompass its own set of varying theoretical perspectives including operant, phenomenological, information processing, social cognitive, volitional, Vygotskian, and cognitive constructivist approaches, which can be studied in detail in Zimmerman and Schunk (2001), and which share a few common features.

SRL theories assume that (a) students can personally improve their ability to learn through selective use of metacognitive and motivational strategies; (b) can proactively select, structure, and even create advantageous learning environments; and (c) can play a significant role in choosing the form and amount of instruction they need. (Zimmerman, 2001, p.5)

Of primary importance is the opportunity for a learner to choose what they want to learn, why they want to learn it, with whom and where the learning will take place, and how much they need to learn (Zimmerman, B. & Schunk, D., 2001, p. 301). Instructional designers can take the principles of self-regulated learning into consideration by providing opportunities for learners to control some aspects of their learning environment.

Relevance to Instructional Design

Much of the research done in cognitive science has been done in laboratory settings without direct application to educational settings. There is a need for instructional design to bridge the gap between learning research and educational practices according to Ertmer and Newby (1993, p. 50). Different theories may be appropriate for use in different learning environments and for different learners. For example, behaviorist principles of stimulus and response can be useful during the learning of facts, such as the multiplication tables. However, cognitive theories are generally useful for more complex learning tasks.

According to cognitivist learning theories, a primary goal is to transfer knowledge to the learner in the most efficient way by allowing the learner to use the most effective cognitive strategies to encode information. Therefore, an instructional designer must consider both the learning task requirements and the current capabilities of the learner. By conducting a cognitive task analysis, the designer can determine the learner's current level of learning skills and the most efficient presentation of information. Since cognitivist theories support the active involvement of the learner, goal setting, planning, and self-monitoring are strategies that should be encouraged. When processing new information, it can be helpful for designers to provide opportunities for learners to organize the material in ways that connect to prior knowledge or personal experiences (Ertmer & Newby, 1986, pp. 60-61).

A general principle of instructional design associated with cognitivism is that information will be more efficiently processed if it is provided in manageable pieces. Therefore, presenting information in a way that reduces the load on working memory will facilitate encoding in long-term memory. Use of feedback is also important. Unlike with behaviorism where the purpose of feedback is to strengthen cue and response, in cognitivism feedback is used to provide the learner with information about the effectiveness of their strategies. Therefore, instructional designers should plan ways for learners to receive prompt feedback on their efforts so that the learners may more effectively plan ahead for future learning situations.

Conclusion

The cognitivist approach to learning assumes that the learner uses cognitive processes as an active participant in the learning process. The variety in the learning objectives and student capacities in any given situation require an instructional designer to have a breadth and depth of knowledge of instructional theories in order to meet the needs of each situation. There is no one theory to rule them all. (Apologies to J.R.R. Tolkien.) However, the principles of cognitivism provide useful paradigms for instructional designers as they create effective learning environments to meet the needs of a wide range of learners.

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Previous Citation(s)

Michela, E. (2018). Cognitivism. In R. Kimmons, *The Students' Guide to Learning Design and Research*. EdTech Books. Retrieved from https://edtechbooks.org/studentguide/cognitivism