

Jeroen J.G. van Merriënboer and Anique B.H. de Bruin

---

## Abstract

What is the most important factor influencing human learning? Different instructional theories give very different answers to this question, because they take different perspectives on learning and thus focus on other desired learning outcomes, other methods affecting learning processes, and other conditions under which learning takes place. This chapter describes how eight prevailing research paradigms have influenced and still strongly influence theory development in the field of educational communications and technology. According to the perspective of Gestalt psychology, the most important factor influencing learning is insight and understanding; according to behaviorism and neo-behaviorism, it is reinforcement; according to developmental psychology, it is the learner's stage of cognitive development; according to cultural-historical theory, it is interaction with the world; according to information processing theory, it is active and deep processing of new information; according to cognitive symbolic theory, it is what the learner already knows; according to cognitive resource models, it is the limited processing capacity of the human mind, and according to social constructivism, it is the social construction of meaning. It is argued that research is typically done within one particular paradigm, but that researchers should be conscious of the fact that paradigms heavily affect their research methods and findings. Moreover, researchers should be open to alternative theories and paradigms because new developments often take place at the interface between paradigms.

---

## Keywords

Research paradigm • Gestalt psychology • Behaviorism • Developmental psychology • Cultural-historical theory • Information processing theory • Symbolic cognitive theory • Cognitive resource theory • Social constructivist theory

---

## Introduction

Instructional theories are concerned with instructional methods that affect learning. Learning refers to the act, process, or experience of gaining knowledge, skills, and attitudes and as such, learning is inherent to all human life. People learn by doing, by exploring, by listening, by reading books, by studying examples, by being rewarded, by discovering, by making and testing predictions, by trial-and-error, by teaching, by abstracting away from concrete experiences, by observing others, by solving problems, by analyzing information, by repetition, by questioning, by paraphrasing information,

---

J.J.G. van Merriënboer (✉)  
Department of Educational Development and Research and Graduate  
School of Health Professions Education, Maastricht University,  
P.O. Box 616, 6200 MD, Maastricht, The Netherlands  
e-mail: j.vanmerrienboer@maastrichtuniversity.nl

A.B.H. de Bruin  
Department of Educational Development and Research and Graduate  
School of Health Professions Education, Maastricht University,  
P.O. Box 616 6200 MD, Maastricht, The Netherlands

Department of Psychology, Erasmus University Rotterdam,  
Burgemeester Oudlaan 50, 3062 PA Rotterdam, The Netherlands

by discussing, by seeing analogies, by making notes, and so forth and so forth. Learning is an extremely broad concept and this makes it hard to answer the question of what the main factors influencing learning are, and thus to identify instructional methods that optimize learning. Taking a particular perspective on learning helps to identify relevant factors. The main question that is answered in this chapter is this: “how do perspectives on learning and research paradigms help researchers in the field of educational communications and technology to develop instructional theories?”

The first section of this chapter takes a closer look at instructional theories which relate instructional methods to learning outcomes and also identify conditions that affect the relationships between methods and outcomes, such as characteristics of the learners, of the learning tasks or learning domain, and of the context in which learning takes place. Different instructional theories typically focus on different sets of desired outcomes, different methods, and different conditions under which learning takes place. The second section explains how the development of theories takes place within particular research paradigms. Eight prevailing paradigms in the field of educational communications and technology are discussed. Within the same paradigm, theories can be compared with each other and theories with the strongest explanatory power are likely to survive. In contrast, theories originating from different paradigms are very hard to compare with each other because they have little in common. Yet, a reconciliation of paradigms might be possible after deep revisions, leading to new developments and research lines. The third Discussion section examines implications for doing research in the field of educational communications and technology.

---

## The Infinite Universe of Instructional Theories

Instructional theories relate instructional methods to each other and to learning processes and learning outcomes. The main elements of instructional theories are thus instructional methods, which specify what the instruction looks like, and instructional outcomes, which specify learning outcomes and processes associated with these instructional methods. A further common distinction is between descriptive instructional theories, which primarily explain the relationships between instructional methods and learning outcomes or processes, and instructional design theories, which prescribe the best instructional methods helping learners to reach desired outcomes (also called “prescriptive” theories). Most instructional theories distinguish different categories of instructional methods or deal with only one or a few of those categories. Reigeluth (1983), for example, makes a distinction between (a) organizational methods, which deal with the way in which instruction is arranged and sequenced, (b) delivery

strategies, which are concerned with the media that are used to convey information to students, and (c) management strategies, which involve the decisions that help the learners to interact with the activities designed for learning.

Instructional *design* theories typically contain a taxonomy of learning outcomes, which makes it possible to classify the desired outcomes and then to select the most suitable instructional method or methods for helping learners to reach these outcomes. The taxonomies of Bloom and Gagné are still in wide use. In the cognitive domain, Bloom (1956) makes a distinction between knowledge, comprehension, application, analysis, synthesis, and evaluation and he describes suitable methods for teaching each of these outcomes. Gagné (1968) makes a distinction between five domains (perceptual-motor skills, attitudes, verbal information, cognitive strategies, and intellectual skills), and in the intellectual skills domain, he makes a further distinction among discrimination, concrete concepts, defined concepts, rules, and higher-order rules. Like Bloom, he describes instructional methods for helping learners to reach each of these outcomes. More recent instructional design models have further refined taxonomies of learning (e.g., Merrill’s performance-content matrix, 1983) or, alternatively, focused on helping students learn highly integrated sets of qualitative different outcomes (i.e., *complex learning*, van Merriënboer, Clark, & de Croock, 2002; van Merriënboer, Kirschner, & Kester, 2003).

Although instructional theories deal with the relationships between instructional methods and learning processes and/or outcomes, it should be stressed that these are never straightforward relations. There are numerous conditions that affect the relationships between methods and outcomes. These conditions deal, for example, with the characteristics of the learners, with the nature of the learning domain or learning tasks, and with the context in which learning takes place. Relevant factors with regard to the learners are prior knowledge, general ability, age, limitations, and learning styles. For example, students with low prior knowledge learn more from studying examples than from solving the equivalent problems, but this pattern is reversed for students with high prior knowledge (Kalyuga, Ayres, Chandler, & Sweller, 2003). Relevant factors with regard to the learning domain or tasks are potential dangers, tools used, the epistemology of the domain, task complexity, and standards. For example, a safe task is better practiced on-the-job than in a simulated environment, but this pattern is reversed for a dangerous task. Finally, relevant factors with regard to the context are available time, money, equipment, culture, and setting (e.g., military, school, business). For example, inquiry methods may be superior to expository methods if ample instructional time is available, but this pattern is reversed with limited instructional time.

In the field of education, there are simply no instructional methods that either work or do not work regardless of conditions.

At best, there are some methods that help learners to reach particular learning outcomes under particular conditions. Berliner refers in his article *Educational research: The hardest science of all* (2002) to this problem as the *ubiquity of interactions*, leading to a combinatorial explosion of factors influencing learning. Consequently, the universe of instructional theories is practically infinite and each instructional theory can only try to describe a small fraction of this whole universe. This is where research paradigms come into play. Such paradigms help us to determine the limits of “our” fraction of the universe, and to develop families of competing instructional theories that can be sensibly compared with each other.

## Paradigms and Perspectives on Learning

In his book *The structure of scientific revolutions*, Kuhn (1996) introduced the term paradigm to refer to a set of practices that define a scientific discipline or sub discipline. The practices refer, amongst others, to what is studied, the kind of research questions that are posed and how these are structured, how and with what tools studies are conducted, and how results are analyzed and interpreted. In short, a paradigm is a specific way of viewing reality, excluding alternative ways of viewing reality. Consequently, different paradigms are incommensurable, meaning that no meaningful comparison between them is possible without fundamental modification of the concepts that are an intrinsic part of the paradigms being compared. The same is true for the theories developed within a particular paradigm. Within the same paradigm, theories can compete with each other and the theory with the strongest explanatory power is likely to survive. But theories developed in different paradigms cannot be sensibly compared with each other without far-reaching modifications because they represent fundamentally different ways of looking at reality. Yet, a reconciliation of paradigms after necessary deep revisions may lead to a novel perspective on learning and new research lines.

The remainder of this section briefly discusses eight prevailing paradigms in the field of educational communications and technology and their central perspective on learning: Gestalt psychology, behaviorism and neo-behaviorism, developmental psychology, cultural-historical theory, information processing theory, symbolic cognitive theories, cognitive resource theories, and social constructivism.

### Gestalt Psychology

Gestalt psychology originated in the early twentieth century in Germany, with Wertheimer, Koffka, and Kohler as most important representatives (Ash, 1998). The word “Gestalt”

refers to the essence of an entity’s complete form, and the phrase “the whole is greater than the sum of its parts” is often used when explaining Gestalt theory. Gestalt psychologists analyze perceptual and thinking processes as reorganizing or relating one aspect of a problem situation to another, which may result in structural understanding. This involves restructuring the elements of a problem situation in a new way so that a problem can be solved. In this process, it may be important to give hints to the problem solver to help him or her break out of old ways of organizing the situation (called “Einstellung”). The new way of looking at the problem is accompanied by “insight,” the “magical flash” or “Aha-erlebnis” that occurs when the solution suddenly falls into place. Gestalt psychologists hold that positive transfer from one task to another is achieved by arranging learning situations so that a learner can gain insight into the problem to be solved. This type of learning is thought to be permanent and reorganized knowledge may yield deep understanding and thus transfer to new situations.

Luchins (1961) described the implications of Gestalt psychology, and in particular the work of his teacher Max Wertheimer, for the field of educational communications and technology. Wertheimer stressed the importance of thinking about problems as a whole and introduced the distinction between productive thinking, which is an unplanned response to situations and environmental interactions yielding insight and understanding, and reproductive thinking, which is solving a problem with previous experiences and what is already known. Productive thinking is seen as the most important goal of education (*see* Wertheimer, 1982). Central to Wertheimer’s approach is that learners are conceptualized as active constructors of knowledge rather than passive recipients of information; they actively seek to make sense of the environment by imposing structure and order on stimuli encountered through direct perception and experience. In this view, instruction and teaching should help to “... illustrate clear-cut structures as well as various degrees of structurization; present hints as to the next step in proceeding; pace the learning; illustrate required elements; point to gaps in the learning process, and illustrate sensible, productive ways of dealing with a particular task in contrast to stupid ways” (Luchins, 1961, p. 27). If researchers working in the Gestalt tradition were asked what the most important factor influencing learning is, their answer would be: “*reaching insight and understanding through restructuring.*”

### Behaviorism and Neo-behaviorism

During the first part of the twentieth century, partly in parallel with the florescence of Gestalt psychology in Europe, the intellectual climate in the USA emphasized the individual’s possibilities to develop and achieve great things (the American Dream).

The idea that behavior is malleable and education can foster excellence made learning one of the paramount concerns of American psychology. According to behaviorism, which was flourishing in those days, learning at all levels, be it a monkey learning to collect candy by pushing a lever, or a child in elementary school learning to subtract, is guided by a set of basic laws. Two of these main laws are termed classical conditioning and operant conditioning. Classical conditioning refers to the phenomenon that a neutral stimulus (a bell) can lead to an automatic response (salivation in a dog) after it is associated a number of times with a stimulus that in itself triggers the automatic response (food). Ivan Pavlov (1927), the discoverer of this phenomenon, termed this automatically learned association a conditioned reflex. In contrast, operant conditioning happens when the learner's behavior is stimulated (usually referred to as reinforced) by a positive outcome, or is punished by a negative outcome (Thorndike, 1911). Consider a cat inside a cage trying to get out. It shows all sorts of random behavior, for example, biting the bars, jumping up and down, and pushing a lever. The latter behavior opens the cage, but only after repeated execution of that behavior is there enough reinforcement for the cat to learn the association between the lever and the opening of the cage. Skinner (1938) insisted on a sharp distinction between classical conditioning and operant conditioning; in the former the conditioned response is set off automatically by an external stimulus, whereas in the latter behavior is voluntarily executed by the learner.

Behaviorists agreed that most of learning is guided by these relatively simple laws, and that cognitive processes played a minor role, if any role at all. They viewed the child's mind as a blank slate, and emphasized the all-decisive effect of the environment (Fontana, 1984). Reinforcement, and to a lesser extent punishment, shapes learning and should be used by educators to create desired behavior and prevent unwanted behavior. In the field of educational communications and technology, *programmed learning* was based on behaviorist insights (Skinner, 1968). It consists of small learning steps ("frames") that the learner goes through in a self-paced way. Each frame contains a segment of information and a question on which the learner will be provided feedback. Behaviorists' answer to the question what the most important factor influencing learning is, would simply be: "*Reinforcement!*"

## Developmental Psychology

The most influential scientist in the history of developmental psychology still is Jean Piaget. He was the first to study what is now termed cognitive development, focusing on how children learn to understand the world and how their cognitive abilities expand during childhood. He was influenced by Gestalt psychology and its study of how structural understanding

develops. His theory departed from the idea that cognitive development follows qualitatively different stages, each with its own distinctive characteristics. Until then, children were mainly viewed as miniature adults, but Piaget created room for the idea of a separate life phase. Piaget described four developmental stages, following a similar age line across individuals (Piaget & Inhelder, 1962). During the first stage, the sensorimotor stage (0–2 years), children learn through sensorimotor experiences, e.g., seeing, kicking, and hitting objects. Children learn to realize that their actions can influence the world, and by the end of this stage they have acquired the ability to mentally represent objects in their heads. Children in the preoperational stage (2–7 years) show an enormous increase in the ability to mentally represent objects, illustrated mostly by the development of language. The third stage, the concrete operational stage (7–11 years), is marked by an increased flexibility of these mental representations; children's thinking becomes more flexible, logical, and organized than before. A major milestone is solving the conservation task: Children understand that the amount of liquid in a glass does not change when poured from a tall glass into a short, wide glass. The final stage, the formal operational stage (11 years and beyond), is characterized by the development of abstract, scientific thinking. Whereas children in the concrete operational stage can reason about objects in the real world, formal operational children are able to do so about abstract situations.

When transferring insights from cognitive development to learning, it is clear that education should be adapted to the characteristics of the specific stage the learner is in. A one-year-old infant should be encouraged to physically stimulate his environment in order to learn. The pre-operational child, moreover, will only learn when confronted with real-life examples involving limited reasoning. The concrete operational child can be challenged with more complex examples, for instance, classifying objects according to a rule, as long as the examples are concrete and close to the child's experiences. Abstract reasoning is reserved for the formal-operational child. Piagetians emphasize active discovery learning, adapted to the child's developmental level. Developmental psychologists would argue that the most important factor influencing learning is: "*the cognitive-developmental stage the learner finds himself in.*"

## Cultural-Historical Theory

Cultural-historical theory is rooted in dialectical materialism, the official philosophy of Communism claiming that everything is material and that change takes place through the struggle of opposites (i.e., thesis-antithesis-synthesis). Lev Vygotsky (1978) is the founding father of cultural-historical theory in the 1920s. His theory focuses on human

development as the interplay between the individual mind and society, as expressed in his famous statement “the mind grows through interaction with other minds.” On a broader scale, cultural-historical theory stresses that human beings live and learn in an environment transformed by the activity of prior members of their species; the transformations from one generation to the next generation are the result of the human ability to create and use artifacts. Furthermore, cultural mediators such as words, signs, and symbols enable the development of higher mental functions in this transformative process. As a result, the specific knowledge gained by children in this process also represents the shared knowledge of a culture—a process known as *internalization*. A popular theory in the cultural-historical tradition is activity theory, which was founded by Leont’ev and further developed by Engeström (see Engeström, Mietinen, & Punamaki, 1999), who proposes a scheme of activity containing three interacting entities—the individual, the objects and tools, and the community.

With regard to educational communications and technologies, cultural-historical theories stress the importance of social interaction with the world. A central concept in this respect is Vygotsky’s zone of proximal development. The basic idea is that children (and adult learners) learn by interacting with the world and with others, that is, by performing meaningful tasks. At the lower limit of the zone of proximal development are tasks that the learner can perform independently; at the upper limit of the zone are the tasks that the learner can only perform thanks to the support and guidance offered by others, such as a teacher, parent, or more experienced peer. Thus, the zone of proximal development captures the skills that are in the process of maturing, and learning is optimized if tasks are in this zone and can be accomplished only thanks to support and guidance provided by others. A closely related concept is scaffolding, meaning that the given support and guidance gradually decreases as learners acquire more knowledge and skills. Over the course of a learning process, a more-skilled person thus adjusts the amount of guidance to fit the learners’ current performance. In the cultural-historical perspective, dialogue is an important tool in this process because spontaneous concepts of the learner are then confronted with the rational and more useful concepts of the teacher or a more experienced peer. If researchers in the cultural-historical paradigm were asked what the most important factor influencing learning is, their answer would be “*social interaction with the world and with others.*”

### Information Processing Theories

The analogy between the human mind and a computer is drawn from information processing theories, which were

mainly developed in the 1950s and 1960s. Concepts that are still used daily in psychology, such as memory storage and retrieval, find their origin in the information processing approach to cognition (Broadbent, 1958; Neisser, 1967). Where behaviorism stressed the importance of the environment, the information processing approach puts a strong emphasis on the internal cognitive state of humans, and aimed to study the complexity of their cognitive processes. Information processing theorists viewed the human mind as an information processing device containing distinct components: A sensory register, a short-term memory, and a long-term memory. The sensory register is an extremely short-term buffer of information, long enough to determine (unconsciously) whether information should be passed on to short-term memory or, alternatively, be discarded. Short-term memory is comparable to the central processing unit of a computer, being all that is in the direct and immediate attention of the individual, limited in capacity and duration. Short-term memory integrates information from long-term memory and the current environment. Long-term memory refers to all the knowledge that is stored in the human brain for long-term use. Knowledge in long-term memory that is not currently used is inactive, but can be retrieved and manipulated in short-term memory when necessary.

The implications of information processing theories for education lie in the supposed three-component architecture of the human mind. Educators therefore need to take into account the computer-like structure of the human mind, not only receiving information, but actively processing it as well ( Craik & Lockhart, 1972). Grouping information into meaningful parts (referred to as chunking) increases the chances of remembering the information and reduces short-term memory load. Moreover, instruction should focus on rehearsal of information in short-term memory to enable storage in long-term memory. When a learned procedure is rehearsed often enough, it becomes automatized and can be executed without effort. Finally, learners should be stimulated to actively retrieve information from long-term memory when necessary and use it in short-term memory. Information processing theorists would argue that the most important factor influencing learning is: “*the active mental processing of information.*”

### Symbolic Cognitive Theories

Symbolic cognitive theories build on the computer metaphor introduced by information processing theories, but describe knowledge in such a way that meaning is conveyed. A basic distinction is between models that describe declarative knowledge and models that describe procedural knowledge. Declarative knowledge refers to representations of the outside world and is typically modelled in semantic or propositional



networks (Quillian, 1967), which may vary from plain facts, via simple schemas (e.g., concepts, principles), to highly complex schemas (e.g., conceptual or causal models of a complex domain). This notion reflects ideas from schema theory as introduced by Piaget (1975, original work 1929) and Bartlett (1932). Procedural knowledge refers to cognitive processes that operate on these representations; it is typically modelled in productions or cognitive rules (Anderson, 1993), which link particular conditions to cognitive or motor actions (IF condition THEN action). Symbolic cognitive theories make it possible to give a highly detailed description of to-be-learned knowledge in a process of Cognitive Task Analysis (CTA; Clark, Feldon, van Merriënboer, Yates, & Early, 2008) and to develop computer programs that model this knowledge.

An example of an instructional theory largely based on symbolic cognitive theories is van Merriënboer's four-component instructional design model (4C/ID; 1997, 2007). This model describes learning environments aimed at complex learning as built from four components: (1) learning tasks, which provide the backbone of an educational program, (2) supportive information, which provides the information helpful to perform nonroutine aspects of learning tasks (e.g., problem solving, reasoning), (3) procedural information, which provides the just-in-time information helpful to perform routine aspects of learning tasks, and (4) part-task practice, which helps to automate selected routine aspects of learning tasks. Components 1 and 2 are based on theories of schema construction or declarative learning, in particular, models of inductive learning (i.e., learning from different concrete experiences) for learning tasks, and models of elaboration (i.e., learning by connecting new information to what you already know) for supportive information. Components 3 and 4 are based on theories of schema automation or procedural learning, in particular, models of knowledge compilation (i.e., embedding new information in cognitive rules) for procedural information, and models of strengthening (i.e., automating cognitive rules by repetition) for part-task practice. A learning environment built from the four components thus promotes four simultaneous learning processes in a process of complex learning. Those learning processes will be more effective as the learner has more knowledge to begin with, and instructional methods that may be effective for learners with little prior knowledge will often be ineffective for learners with high prior knowledge (i.e., the "expertise reversal effect"; Kalyuga et al., 2003). If researchers working in the cognitive symbolic paradigm were asked what the most important factor influencing learning is, their answer would be similar to the well-known statement of Ausubel (Ausubel, Novak, & Hanesian, 1978): "*The most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.*"

## Cognitive Resource Theories

Like cognitive symbolic models, cognitive resource theories build on the computer metaphor of the human mind. But in contrast to symbolic cognitive models, resource models do not refer to semantic representations in memory that convey meaning but limit themselves to a specification of human cognitive architecture and, especially, the capacity of memory systems. Most resource models make a distinction between working memory and long-term memory to explain why available cognitive resources for learning and performance are limited. Whereas the capacity of long-term memory is virtually unlimited, working memory is very limited in duration and in capacity. Information stored in working memory and not rehearsed is lost within 30 s (Baddeley, 1992) and the capacity of working memory is limited to Miller's (1956) famous  $7 \pm 2$  elements or, according to more recent findings, even  $4 \pm 1$  element (Cowan, 2001). The interactions between working memory and long-term memory are even more important than the direct processing limitations of working memory itself (Sweller, 2004). The limitations of working memory only apply to new, yet to be learned information that has not been stored in long-term memory. When dealing with previously learned information stored in long-term memory, the limitations disappear because constructed schemas in long-term memory can be handled as one element in working memory.

In the field of instructional design, cognitive load theory (Sweller, van Merriënboer, & Paas, 1998; van Merriënboer & Sweller, 2005, 2010) is a popular theory based on cognitive resource theories. The main assumption is that effective instruction should limit extraneous or ineffective cognitive load on working memory, so that the available resources can be used for genuine learning, that is, the construction and automation of schemas in long-term memory. One process that causes a high extraneous cognitive load is, for example, conventional problem solving. For novice learners, problem solving is only possible thanks to means-ends analysis, which requires the student to consider differences between the goal state and the given state of the problem, and to search blindly for solution steps to reduce those differences. This process is exceptionally expensive in terms of working memory capacity and bears no relation to schema construction processes concerned with learning to recognize problem states and their associated solution steps. Problem solving and learning to solve problems are thus two very different and incompatible processes! For teaching problem solving, cognitive load researchers devised more effective problem formats such as goal-free problems (Ayres, 1993), worked-out examples (Renkl, 1997), and completion problems (Van Merriënboer, 1990). If researchers working in the cognitive resource paradigm were asked what the most important factor influencing learning is, their answer would be: "*The limited processing capacity of the human mind.*"

## Social Constructivist Theories

Social constructivism has its roots in developmental psychology (Jean Piaget, 1896–1980†), cultural-historical theory (Lev Vygotsky, 1896–1934†) and, to a somewhat lesser degree, Gestalt psychology (Max Wertheimer, 1880–1943†). Jean Piaget was the first to emphasize the constructive nature of the child’s mind: The child actively attempts to construct understanding of the outside world. Wertheimer stressed the importance of productive thinking as a reconstructive act. Vygotsky, who was also influenced by Gestalt psychology, independently came to similar conclusions as Piaget with regard to the importance of constructivist action to promote learning (see Dockrell, Smith, & Tomlinson, 1997). Social constructivism deviates from Piaget’s idea of constructivism, in that it stresses, like cultural-historical theory, the importance of *social* interaction to achieve understanding (Palincsar, 1998). It argues that knowledge and even our idea of reality arise through social relationships and interactions. That is, everything we know we have learned by communicating and interacting with others, either personally or through multimedia. The social constructivist is interested in how an individual learns as a result of these interactions. Radical constructivism (Von Glasersfeld, 1995) takes these ideas a few steps further, stating that all knowledge is created by the human mind and therefore it is impossible to know to what extent this corresponds to ontological (true) reality.

Social constructivism was developed in the 1990s and is very popular in education and educational research today. It is not surprising that it puts a strong focus on student discussion and learning through multimedia. Many popular educational formats such as problem-based learning and computer supported collaborative learning (CSCL) have their roots in social constructivism. According to social constructivism small or large group discussion increases student motivation, and builds a deeper understanding of what students are learning. It also provides support for self-regulation of learning, as students can test the quality of their knowledge on that of peer students. Jonassen (Jonassen, Carr, & Yueh, 1998) advocates the use of cognitive tools or mindtools from a social-constructivist perspective. Cognitive tools refer to computer tools that are designed to foster information gathering and learning. These include concept mapping software, spreadsheets, but also internet forums and Google. They are preferable for teacher-centered education as they actively engage the learner and improve students’ sense of ownership of their knowledge. Social constructivist theory discourages the use of traditional lectures, because of the minimal opportunities for communication and discussion with the teacher and fellow students. According to social constructivism the most important factor influencing learning would be: “*The construction of meaning and knowledge through the interaction with others.*”

## Discussion and Conclusions

Instructional theories relate instructional methods to each other and to learning processes and learning outcomes. The relations between methods and outcomes are, however, never straightforward. There are numerous conditions that affect the relationships between methods and outcomes: This ubiquity of interactions leads to a combinatorial explosion of factors influencing learning. Consequently, the universe of instructional theories is practically infinite and each instructional theory is dealing with only a small fraction of the whole universe. Scientific paradigms determine which fraction of the universe theories developed within this paradigm are looking at. Eight dominant paradigms in the field of educational communications and technologies were discussed, each with their own perspective on learning and their own focus on one or more particular factors influencing learning. Gestalt psychology focuses on how learners reach *insight and understanding*; behaviorism and neo-behaviorism focus on the effects of *reinforcement* on learning; developmental psychology focuses on the *stage of cognitive development* of the learners; cultural-historical theory focuses on the learners’ *interaction with the world*; information processing theory focuses on *active mental processing* by the learners; symbolic cognitive theories focus on the learners’ *prior knowledge*; cognitive resource theories focus on the *limited processing capacity* of the human mind, and social constructivism focuses on the *social construction of meaning* by learners.

Because the paradigms and theories developed within these paradigms have little in common, it is often difficult if not impossible to compare them. The different ways of looking at reality may produce different results. For example, researchers working in the neo-behaviorist paradigm report consistent positive results of reinforcement on learning outcomes (e.g., Flora, 2004), while researchers working in the social constructivist paradigm also report negative effects because external reinforcements may harm intrinsic motivation (e.g., Sivan, 1986). Both claims are based on sound research but nevertheless reach different conclusions because research questions, methods, and interpretations of results are fundamentally different. This also makes it difficult to reconcile the different claims (but see Cameron & Pierce, 2002). In this respect, Berliner (2002) also refers to “decade by findings interactions,” meaning that results may also be different depending on the period in which the research has been done. For example, in the 1960s sound research was done on differences in achievement motivation between boys and girls. Nowadays, these results are worthless because the feminist revolution has worked its way through society—changes in context have changed the results of the interaction under study.

Whereas different paradigms may have little in common, progress in one particular paradigm is often made by lending ideas from other paradigms. For example, Piaget's developmental psychology is influenced by ideas on structural understanding from Gestalt psychology; cognitive symbolic theories and cognitive resource models both build on information processing theory; cognitive symbolic theories acknowledge the importance of limited working memory and also include ideas from schema theory originally developed by Piaget (1929) and Bartlett (1932), and social constructivist theories include ideas from developmental psychology, cultural-historical theory, and Gestalt psychology. Especially some of the newer paradigms have borrowed from many of the older ones. The influential report *How people learn* (National Research Council, 2000) reflects much of the current thinking in these newer paradigms.

Research paradigms have clear implications for both research and design. Researchers in different paradigms do research on different things because they focus on different learning outcomes, methods, and conditions. Consequently, they will also focus on the design of different instructional measures, such as hints (Gestalt psychology), rewards (behaviorism), discovery learning (developmental psychology), dialogue (cultural historical theory), programmed instruction (information processing theory), learning by doing (symbolic cognitive theories), example-based learning (cognitive resource models), or collaborative knowledge building tools (social constructivism). Yet, although different ways of looking at reality may produce different results, they do not exclude the identification of basic principles in learning, just as a biologist doing research on ecosystems on Earth and an astronomer doing research on the climate on Mars might reach the same conclusions on conditions for life on a planet. Merrill's work on "first principles of instruction" (2002), for example, shows that five principles are quite common over different paradigms, including paradigms that are often contrasted with each other such as symbolic cognitive theories and social constructivist models. The first principles state that learning is promoted when learners: (1) work on meaningful problems, (2) activate previous experience, (3) observe what is to be learned, (4) apply what has been learned, and (5) integrate what has been learned into their everyday life.

What are the implications of the existence of different paradigms and perspectives on learning for doing research in the field of educational communications and technology? First, it should be clear that educational researchers should be conscious of the paradigm they are working in, including its opportunities and limitations. Second, within this paradigm, they should deliberately contribute to theory development because researchers without a theory are like wanderers in the desert and their research results will be blown away like sand. Third, researchers should always have an open mind

for research based on competing theories and paradigms, because radically new ideas and perspectives will most likely develop at the interface between paradigms.

## References

- Anderson, J. R. (1993). *Rules of the mind*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- \* Ash, M. G. (1998). *Gestalt psychology in German culture, 1890–1967: Holism and the quest for objectivity*. Cambridge, UK: Cambridge University Press.
- Ausubel, D., Novak, J., & Hanesian, H. (1978). *Educational psychology: A cognitive view* (2nd ed.). New York: Holt, Rinehart & Winston.
- Ayres, P. L. (1993). Why goal-free problems can facilitate learning. *Contemporary Educational Psychology*, 18, 376–381.
- Baddeley, A. (1992). Working memory. *Science*, 255, 556–559.
- Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. Cambridge, UK: Cambridge University Press.
- \* Berliner, D. C. (2002). Educational research: The hardest science of all. *Educational Researcher*, 31(8), 18–20.
- Bloom, B. S. (1956). *Taxonomy of educational objectives, handbook 1: The cognitive domain*. New York: David McKay Co Inc.
- Broadbent, D. E. (1958). *Perception and communication*. London, UK: Pergamon Press.
- Cameron, J., & Pierce, W. D. (2002). *Rewards and intrinsic motivation: Resolving the controversy*. Westport, CT: Bergin & Garvey.
- Clark, R. E., Feldon, D. F., van Merriënboer, J. J. G., Yates, K. A., & Early, S. (2008). Cognitive task analysis. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed., pp. 577–594). Mahwah, NJ: Erlbaum/Routledge.
- Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*, 24, 87–114.
- \* Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 671–684.
- Dockrell, J., Smith, L., & Tomlinson, P. (1997). *Piaget, Vygotsky and beyond: Central issues in developmental psychology and education*. London: Routledge.
- Engeström, M. Y., Miettinen, R., & Punamaki, R.-L. (Eds.). (1999). *Perspectives on activity theory*. Cambridge, UK: Cambridge University Press.
- Flora, S. R. (2004). *The power of reinforcement*. New York: State University of New York Press.
- Fontana, D. (Ed.). (1984). *Behaviorism and learning theory in education*. Edinburgh: Scottish Academic Press.
- Gagné, R. M. (1968). Learning hierarchies. *Educational Psychologist*, 6, 1–9.
- Jonassen, D. H., Carr, C., & Yueh, H. (1998). Computers as mindtools for engaging learners in critical thinking. *TechTrends*, 2, 24–32.
- Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist*, 38(1), 23–31.
- \* Kuhn, T. H. (1996). *The structure of scientific revolutions* (3rd ed.). Chicago: University of Chicago Press.
- Luchins, A. S. (1961). Implications of Gestalt psychology for AV learning. *Educational Technology Research and Development*, 9(5), 7–32.
- Merrill, M. D. (1983). Component display theory. In C. M. Reigeluth (Ed.), *Instructional design theories and models* (pp. 278–333). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development*, 50(3), 43–59.



- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*, 81–97.
- National Research Council. (2000). In M. S. Donovan, J. D. Bransford, & J. W. Pellegrino (Eds.), *How people learn: Bridging research and practice*. Washington, DC: National Research Council, Committee on Developments in the Science of Learning.
- Neisser, U. (1967). *Cognitive psychology*. New York: Appleton-Century-Crofts.
- \* Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology*, *49*, 345–375.
- Pavlov, I. (1927). *Conditioned reflexes*. Oxford, UK: Oxford University Press.
- \* Piaget, J. (1975). *The child's conception of the world (original work published 1929)*. Totowa, NJ: Littlefield Adams.
- Piaget, J., & Inhelder, B. (1962). *The psychology of the child*. New York: Basic Books.
- \* Quillian, M. R. (1967). Word concepts: A theory and simulation of some basic semantic capabilities. *Behavioral Science*, *12*(5), 410–430.
- Reigeluth, C. M. (1983). Instructional design: What is it and why is it. In C. M. Reigeluth (Ed.), *Instructional-design theories and models* (pp. 3–36). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Renkl, A. (1997). Learning from worked-out examples: A study on individual differences. *Cognitive Science*, *21*, 1–29.
- Sivan, E. (1986). Motivation in social constructivist theory. *Educational Psychologist*, *21*(3), 209–233.
- Skinner, B. F. (1938). *The behavior of organisms*. New York: Appleton-Century-Crofts.
- \* Skinner, B. F. (1968). *Technology of teaching*. New York: Appleton-Century-Crofts.
- Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional Science*, *32*, 9–31.
- \* Sweller, J., van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*(3), 251–296.
- Thorndike, E. L. (1911). *Animal intelligence: Experimental studies*. New York: MacMillan.
- Van Merriënboer, J. J. G. (1990). Strategies for programming instruction in high school: Program completion vs. program generation. *Journal of Educational Computing Research*, *6*, 265–285.
- Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills*. Englewood Cliffs, NJ: Educational Technology Publications.
- Van Merriënboer, J. J. G., Clark, R. E., & de Croock, M. B. M. (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology Research and Development*, *50*(2), 39–64.
- \* Van Merriënboer, J. J. G., & Kirschner, P. A. (2007). *Ten steps to complex learning*. Mahwah, NJ: Erlbaum.
- Van Merriënboer, J. J. G., Kirschner, P. A., & Kester, L. (2003). Taking the load of a learners' mind: Instructional design for complex learning. *Educational Psychologist*, *38*(1), 5–13.
- Van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, *17*, 147–177.
- Van Merriënboer, J. J. G., & Sweller, J. (2010). Cognitive load theory in health professional education: Design principles and strategies. *Medical Education*, *44*, 85–93.
- Von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning*. London: The Falmer Press.
- \* Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wertheimer, M. (1982). *Productive thinking*. Chicago, IL: University of Chicago Press.



<http://www.springer.com/978-1-4614-3184-8>

Handbook of Research on Educational Communications  
and Technology

Spector, M.; Merrill, M.D.; Elen, J.; Bishop, M.J. (Eds.)

2014, XXXV, 1005 p. 146 illus., 57 illus. in color.,

Hardcover

ISBN: 978-1-4614-3184-8