

COGNITIVE TASKS AND LEARNING

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Synonyms

Complex tasks, Intellectual tasks, Higher-order tasks, Problem solving tasks

Definition

Cognitive tasks are those undertakings that require a person to mentally process new information (i.e., acquire and organize knowledge / learn) and allow them to recall, retrieve that information from memory and to use that information at a later time in the same or similar situations (i.e., transfer).

Theoretical Background

Cognitivism

The roots of cognitive psychology and the role of cognitive tasks lie with David Ausubel's *Psychology of Meaningful Verbal Learning* (1963) and Robert Gagné's *Conditions of Learning* (1977). According to Gagné cognitive tasks aim at the acquisition of intellectual skills and consist of eight hierarchically organized cognitive processes: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving.

Cognitivism was a response to behaviorism which saw learning as a simple response to environmental stimuli. Ausubel, in response to behaviorism, believed that understanding concepts, principles, and ideas are achieved through deductive reasoning requiring active participation in of a learner whose actions are a consequence of thinking. He called this meaningful learning; as opposed to rote memorization. Gagné identified five major categories of learning (verbal information, intellectual skills, cognitive strategies, motor skills, attitudes), each requiring different internal and external conditions for it to occur.

Schema Theory of Learning

That which is meaningfully learned is organized in schemata. The *schema theory of learning* (Anderson, 1977) views organized knowledge as an elaborate network of abstract mental structures which represent how one understands the world. Schemata (1) are constructed by the learner, (2) are meaningfully organized, (3) are added to and refined as an individual gains experience (Piaget: assimilation), (4) are reorganized when

incoming data makes this necessary (Piaget: accommodation), and (5) are embedded in other schemata and contain sub schemata. In other words, learning can be seen as change in a learner's schemata.

Cognitive Tasks

To effectively mentally process new information, retrieve it from memory and then use it in the same or similar situations – in other words to perform well on cognitive tasks - one must first possess the necessary individual cognitive skills for schema acquisition / schema construction. Then, one must be able to *coordinate* the separate skills that constitute the task. In addition, these skills must be *integrated* with prior knowledge and existing attitudes. Finally, successful performance of cognitive tasks requires *differentiation* by recognizing qualitative differences among the task characteristics that influence the constituent skills that have to be applied.

Cognitive Tasks and Learning

Performing cognitive tasks taxes the learner's limited working memory (cf. Sweller, 1988). In other words it induces significant cognitive load. Because of this, effective learning can only commence if the specific instructions within a cognitive task are properly aligned with cognitive architecture (Van Merriënboer & Kirschner, 2007). In their *Ten Steps to Complex Learning* Van Merriënboer and Kirschner outline an instructional design model based upon a whole-task approach and provide strategies to align instruction to human cognitive architecture and help people learn how to perform the complex cognitive tasks.

Part-task models of skill acquisition dominated the field of instructional design until the late 1980's. In that approach, one aspect of a skill was learned and practiced until mastery, at which time a new – often related aspect of the skill – was then learnt and mastered, et cetera, until the “whole” skill was considered to be mastered. According to Van Merriënboer and Kirschner (2007) such models have three major shortcomings, namely they lead to compartmentalization (i.e., teaching knowledge, skills, and attitudes separately, thus hindering complex learning and competence development), fragmentation (i.e., analyzing a complex learning domain in small pieces corresponding with specific learning objectives, and then teaching it piece-by-piece without paying attention to the relationships between pieces), and limit transfer (i.e., transfer paradox: using instructional methods that are highly efficient to reach specific learning objectives, but that are not suitable to reach transfer of learning.). Due to this, there has been a growing interest in whole-task models of learning and instructional design. In dealing with the learning of cognitive tasks, whole-task models provide an alternative to part-task models. Whole-task models, in contrast, analyze tasks as a coherent, interconnected whole and then teach them from very simple, yet meaningful wholes that are representative for the whole task to increasingly more complex wholes, fostering coordination, integration and transfer of learning.

Whole meaningful tasks, thus, are seen as the driving force for learning. Easy-to-difficult sequencing techniques and learner support and guidance, which may be faded as learners acquire more expertise (i.e. scaffolding), are studied as methods to deal with task complexity. Second, there is a focus on the development of the whole person (i.e., learner-centered) rather than the acquisition of isolated pieces of knowledge, and the learner is co-responsible for a process of competency development. Third, there is a renewed interest in the study of instructional methods that explicitly aim at transfer of learning. Methods that work the best for reaching isolated, specific objectives are often not the methods that work best for reaching integrated objectives and increasing transfer of learning (Van Merriënboer, Kester, & Paas, 2006). A whole-task approach takes this paradox into account and is always directed towards reaching multiple, integrated objectives that go beyond a limited list of highly specific objectives. Therefore, whole-task approaches are characterized by the use of mathemagenic instructional methods that give rise to meaningful learning and transfer.

What This Means

Van Merriënboer and Kirschner (2007) present a series of task types which are well suited to the learner's cognitive architecture and which are also aimed at whole-tasks. Different types of learning tasks can be constructed by manipulating the information given to the learner, the goal state to be achieved, and/or the solution required. Here, for the field of problems in the natural sciences, explanations and examples of the different types.

In a *case-study*, learners receive a media claim, relevant articles and/or information (i.e., facts, theories, et cetera), and a way of reasoning which a scientist uses to support or refute the claim. They must evaluate the quality of the argumentation and the information used.

A *reverse task* presents a goal state and an acceptable solution, but the learners have to trace the implications for different claims (i.e., predict the given). In the context of troubleshooting, for example, learners might be told that a particular component is faulted or has failed and predict the behavior of the system based on this (i.e., what they should observe in order to reach a correct diagnosis themselves). Like case studies, reverse tasks focus learners' attention on useful solutions and require them to relate solution steps to given situations.

An *imitation task* presents a conventional task in combination with a case study of an analogous task. The solution presented in the case study provides a blueprint for approaching the new task, focusing attention on possibly useful solution steps. Imitation tasks are quite authentic, because experts often rely on their knowledge of specific cases to guide their problem solving behavior on new problems—a process known in the field of cognitive science as case-based reasoning.

A *non-specific goal task* stimulates the exploration of relationships between solutions and the goals that can be reached by those solutions. It invites learners to move forward from the givens and to explore the problem space, which helps them construct cognitive schemas. This is in contrast to traditional, goal-specific problems that force learners to work backward from the goal. For novice learners, working backward is a cumbersome process that may hinder schema construction (Sweller, 1988).

A *completion task* provides a given state, criteria for an acceptable goal state, and a partial solution. Learners must complete the partial solution by determining and adding the missing steps, either at the end of the solution or at one or more places in the middle of the solution. A particularly strong point of such tasks is that learners must carefully study the partial solution provided to them, because they will otherwise not be able to come up with the complete solution. Well-designed completion tasks ensure that learners can understand the partial solution and still have to perform a non-trivial completion.

The common element of all of the learning tasks is that they direct the learners' attention to problem states, acceptable solutions, and useful solution steps helping them to mindfully abstract information from good solutions or use inductive processes to construct cognitive schemas that reflect generalized solutions for particular types of tasks.

Important Scientific Research and Open Questions

Cognitive Load

Much research effort has been invested in finding methods to decrease irrelevant cognitive load caused by poor instruction to help learners deal with the complexity of cognitive tasks (Van Merriënboer, Kester, & Paas, 2006). Nowadays research in this area is directed to finding means to combine mathemagenic, whole-task instructional methods with complex cognitive tasks without causing cognitive overload. However, this combination has only been empirically confirmed for a limited number of concrete instructional methods. More research is needed to show that the combination holds across a wide variety of methods.

Learner Expertise

Probably the most important point to consider when designing training programs for cognitive tasks is that the complexity of a task depends on the expertise of the learner. The higher the expertise, the lower the experienced complexity. In a flexible and adaptive learning environment, it should be possible to take differences between individual learners into account when learning tasks are selected. As a consequence, a high-ability student may proceed much faster from simple to complex tasks than a low-ability student, and also need less learning tasks to complete the program. More research is necessary to determine which parameters can be used to most effectively adapt instruction to a learner's needs.

Cross-References

- Cognitive learning
- Cognitive skill acquisition
- Human cognition and learning
- Learning task(s)
- Schema development
- Task sequencing and learning

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