Blueprints for Complex Learning: The 4C/ID-Model

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This article provides an overview description of the four-component instructional design system (4C/ID-model) developed originally by van Merriënboer and others in the early 1990s (van Merriënboer, Jelsma, & Paas, 1992) for the design of training programs for complex skills. It discusses the structure of training blueprints for complex learning and associated instructional methods. The basic claim is that four interrelated components are essential in blueprints for complex learning: (a) learning tasks, (b) supportive information, (c) just-in-time (JIT) information, and (d) part-task practice. Instructional methods for each component are coupled to the basic learning processes involved in complex learning and a fully worked-out example of a training blueprint for "searching for literature" is provided. Readers who benefit from a structured advance organizer should consider reading the appendix at the end of this article before reading the entire article.

☐ The instructional design enterprise is a bit like an ocean liner—huge, slow, ponderous, and requiring large amounts of energy and a great deal of time to move it even one degree off its current path. Recent discussions and developments in the field concern rapid technological and societal changes and the resulting need for very complex knowledge at work (Berryman, 1993; Cascio, 1995); new constructivist design theories for problem solving (Jonassen, 1994; Reigeluth, 1999a; Schwarz, Brophy, Lin, & Bransford, 1999); arguments for new context and technology-based design (Driscoll & Dick, 1999; Kozma, 2000; Richey, 1998); two decades of systematic design research and development by John Anderson (1983, 1993; Anderson & Lebiere, 1998), and innovative work on "first principles of instruction" by designer-researcher David Merrill (2000). These welcome discussions have at least one important goal in common-the gradual evolution of design theory to accommodate complex learning. Future design theory should support the development of training programs for learners who need to learn and transfer highly complex cognitive skills or "competencies" to an increasingly varied set of real-world contexts and settings. In addition, adequate design for complex skills helps overcome findings that under some conditions, inadequate design may cause learning problems (Clark, 1988).

The 4C/ID-model proposed in this article addresses at least three deficits in previous instructional design models. First, the 4C/ID-model focuses on the integration and coordinated performance of task-specific constituent skills rather than on knowledge types, context or presentation-delivery media. Second, the model makes a critical distinction between supportive information and required just-in-time (JIT) information (the latter specifies the performance required, not only the type of knowledge required). And third, traditional models use either part-task or whole-task practice; the 4C/ID-model recommends a mixture where part-task practice supports very complex, "whole-task" learning.

Novices learn complex tasks in a very different way than they do simple tasks. Evidence for this claim can be found in research on learning concepts (Corneille & Judd, 1999), verbal information (Pointe & Engle, 1990), mathematics (Wenger & Carlson, 1996), visual comparison tasks (Pellegrino, Doane, Fischer, & Alderton, 1991) and a variety of complex work skills (Ackerman, 1990), among others. Most design models emphasize instruction in relatively simple learning tasks and assume that a large, complex set of interrelated tasks are achievable as "the sum of the parts"—by sequencing a string of simplified, component task procedures until a complex task is captured. There is overwhelming evidence that this does not work (see van Merriënboer, 1997, for an in-depth discussion of these issues). Existing design models most often assume that knowledge of simple task performance, once acquired, transfers reliably to novel future problems despite considerable evidence to the contrary (e.g., Clark & Estes, 1999; Perkins & Grotzer, 1997).

These relatively new insights about complex learning are presented in a design theory developed originally by van Merriënboer and others in the early 1990s (van Merriënboer, Jelsma, & Paas, 1992). The complete design system and its psychological backgrounds are described in van Merriënboer (1997; see also van Merriënboer & Dijkstra, 1996, for its theoretical basis). This article presents an overview of the most recent version of the design theory, called 4C/ID. It is a version of the model that currently provides the basis for the development of computer-based design tools in a European project called ADAPT^{IT} (Advanced Design Approach for Personalized Training—Interactive Tools).

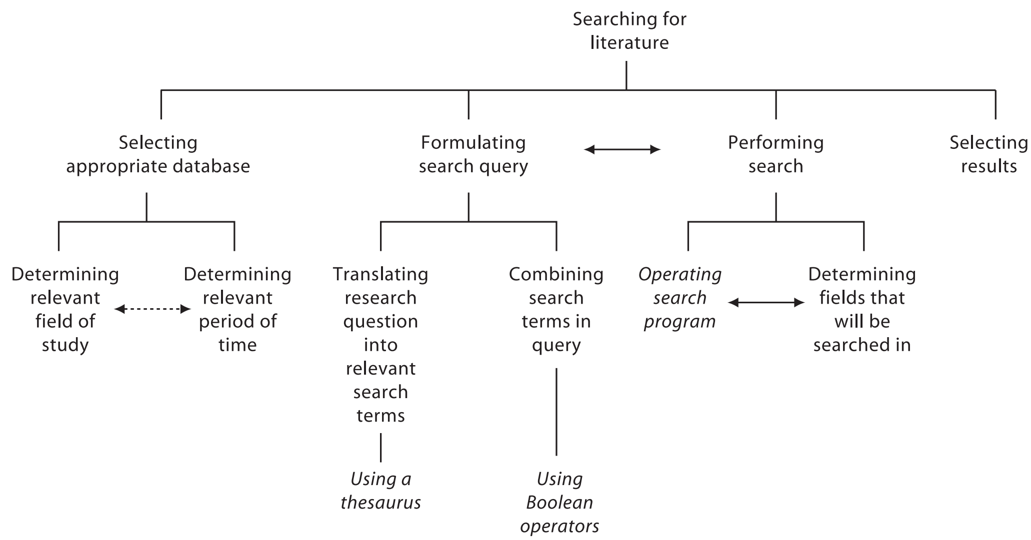
An overview of the 4C/ID-model is given in three parts. First, the elements of complex learning that must be accommodated in design are described conceptually, using a concrete example of the skills necessary to search for documents in a computerized database. Second, a description is presented of the four "blueprint components" (4C) that support complex learning, namely (a) learning tasks; (b) supportive information; (c) JIT information, and (d) part-task practice. Instructional methods are illustrated for each component. Finally, the use of the model for designing adaptive instruction is discussed and some empirical studies that support the effectiveness of the model are briefly reviewed. We will also briefly discuss cognitive task analysis as a method for capturing advance expertise as content for complex training.

COMPLEX LEARNING

Complex learning is always involved with achieving integrated sets of learning goals—multiple performance objectives. It has little to do with learning separate skills in isolation, but it is foremost dealing with learning to coordinate and integrate the separate skills that constitute real-life task performance. Thus, in complex learning the whole is clearly more than the sum of its parts because it also includes the ability to coordinate and integrate those parts. As an illustration, Figure 1 provides a simple description of the *constituent skills* that make up the moderately complex cognitive skill, "searching for relevant research literature." A well-designed training program for complex learning will not aim at trainees' acquiring each of these constituent skills separately, but will instead try to achieve that the trainees acquire the ability to use all of the skills in a coordinated and integrated fashion while doing real-life literature searches.

The skills hierarchy in Figure 1 depicts the two fundamental types of relations between constituent skills that must be taken into account when designing a training program (cf. Gagné's "learning hierarchy," Gagné, Briggs, & Wager, 1992). First, there is a horizontal relationship between coordinate skills that is indicated from left to right. This relationship can be temporal (e.g., you first select an appropriate database and then

Figure 1 ☐ Skills hierarchy for the moderately complex skill "searching for relevant research literature." Nonrecurrent skills are represented in roman font, recurrent skills in italics. Double horizontal arrows with a solid line represent a simultaneous relationship; double horizontal arrows with a dotted line represent a transposable relationship (see text).



formulate the search query for the selected database), simultaneous (e.g., you concurrently formulate a search query and perform the search until you have a relevant and manageable list of results), or transposable (e.g., determining the relevant field of study and determining the relevant period of time can be done in any order or even simultaneously). The second type of relation is the vertical relationship, which is indicated from bottom-to-top between child skills on a certain level and their parent skill one level higher. This relationship signifies that constituent skills lower in the hierarchy enable or are prerequisite to the learning and performance of skills higher in the hierarchy (e.g., you must be able to operate a search program in order to be able to perform a search). In an intertwined hierarchy, additional relations between constituent skills that are important for training design may be added. For instance, similarity relations may indicate constituent skills that are easily mixed up.

Figure 1 also illustrates a typical characteristic of complex learning outcomes. Namely, for expert task performers, there are qualitative differences between constituent skills involved. Some constituent skills are performed in a variable way from problem to problem situation. For instance, formulating a search query involves problem solving and reasoning in order to cope with the specific requirements of each new search. Experts can effectively perform such constituent skills because they have highly complex cognitive schemata available that help them to reason about the domain and to guide their problem solving. Thus, schemata enable *another* use of the same knowledge in a new problem situation, because they contain generalized knowledge, or concrete cases, or both, that can serve as an analogy.

Other constituent skills lower in the hierarchy may be performed in a highly consistent way from problem to problem situation. For instance, operating the search program is a constituent skill that does not require reasoning or problem solving. Experts can effectively perform such constituent skills because their schemata contain rules that directly associate particular characteristics of the problem situation to particular actions. In other words, rules enable the *same* use of identical, situation-specific knowledge in a new problem situation.